ANNALS
OF
The Entomological Society of America

Volume XXIII JUNE, 1930 Number 2

TWELVE NEW MEALYBUGS FROM MISSISSIPPI.
(Homoptera: Coccoidea.)*

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Of the species described in this paper one is a Phenacoccus, two are members of the genus Pseudantonina, four of the genus Pseudococcus, and five of the genus Trionymus. The ants attending these mealybugs were determined by Dr. M. R. Smith.

In a forthcoming paper I recognize the families (1) Diaspidæ and (2) Aclerdidæ of Professor Ferris, the (3) Coccidæ of Mr. Steinwenden, and the (4) Margarodidæ and Ortheziidæ of Dr. Morrison. These groups are based on old subfamilies or genera. It thus becomes necessary to consider as a family also the group Pseudococcinæ, even though it has but within the past year been defined and elevated to subfamily rank by Dr. Morrison (5). Professor Ferris (6) has discussed most of the genera that are at present recognized as belonging to this group.

Pseudococcidæ.

This group is composed of those genera which have one or two pairs of dorsal ostioles, and which typically have small triangular and usually trilocular pores. A common characteristic of many of the members of this family is a covering of cottony or mealy secretion and the presence usually of at least one pair of cerarii.

*Contribution from the Entomology Laboratory of the Mississippi Agricultural Experment Station and State Plant Board of Mississippi. The drawings were made by Mrs. G. G. DeBord, of the DeBord Laboratories, Fort Smith, Arkansas.

Phenacoccus insignis new species.

(Plate I, Figures 1-7.)

Larva.—Body of mounted specimens examined .79 to .85 mm. long, about .46 mm. broad; antennæ six-segmented; tibiæ shorter than tarsi, claws long and slender, each with a denticle; tentorium well developed, ventral surface with quinquelocular disc pores, those of abdomen in transverse rows; dorsal surface with setæ constricted at base, and with trilocular pores; position of cerarii indicated by presence of spines and pores, numbers not determined, anal lobe bearing two large cerarian spines and about three pores, ventral surface of anal lobe with one short and one long seta; anal ring setæ about five-eighths as long as anal lobe setæ.

Adult female.—Body of specimens mounted on slide 3.24 to 3.42 mm. long, 2.31 to 2.64 mm. broad; antennæ nine-segmented; eighth and ninth segments less distinctly separated than preceding segments, seventh and eighth segments subequal in length, distal segment slightly longer; tentorium well developed; legs of usual type, front tibia two and one-third times as long as tarsus, hind tibia three and one-third times as long as tarsus, claw with large denticle, dorsal setæ not numerous, small, constricted at base, ventral setæ of usual type, in transverse rows, about five groups of one long and one short seta on each segment; dorsal and ventral surfaces with trilocular pores, ventral surface with quinquelocular pores in transverse rows and also multilocular pores in region of vulva, seventeen pairs of cerarii, apparently located on slight protuberances, cerarian spines small, varying in number and size, usually about two larger and one to ten smaller, constricted at base, pores more numerous than on adjacent surface but more than their own width apart; a larger or medium sized ceratuba, or possibly more, apparently on each segment on margin, opening to surface through a chitinized protuberance, resembling in shape a frustrum of a cone, which apparently usually bears two stout setæ near base, some segments with additional similar ceratubæ near meson, number apparently variable; anal ring cellular, with two outer rows of cells, in places three rows, single inner row; ventral surface of anal lobe bearing usually one long, two medium, and two small setæ; four smaller setæ located on or near mesal margin of small chitinized area; six anal ring setæ, about two-thirds as long as anal setæ, ovoviviparous.

Host.—Elm bark (*Ulmus* sp.).

Locality.—Columbus, Mississippi: November 30, 1926.

Collected by Dr. M. R. Smith and Mr. J. N. Roney.

Attended by ants (*Crematogaster laeviuscula* var. *clara* Mayr.)

The pores of the cerarii are apparently more numerous in this species than in *Phenacoccus regnillohi* Holl, and there is a distinct chitinized area on the ventral surface of each anal lobe. The original description does not mention this chitinization.

Dr. Morrison says, "I cannot associate this specimen with any species in the collection. From descriptions, it seems closest to *regnillohi* Holl."

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection: and in the coccoid collection of the U. S. National Museum.

Pseudantonina giganticoxa new species.

(Plate II, Figures 1–6.)

Living adult females.—About 1.8 to 2.19 mm. long, 1.4 to 2.19 mm. broad, 1.00 mm. high, yellowish white color with practically no secretion on January 10, when brought into the laboratory, segmentation of thorax and abdomen distinct. Four specimens left in vial until morning after collection had secreted a quantity of white cottony wax threads which entirely surrounded the body extending for about twice the length of the body caudad of it. One specimen had only secreted a small quantity of fine white powdery wax and a few threads. On January 17, the wax on one specimen stood 7 mm. high and curved caudad, the total length equaling the height. The specimens were not fed.

Adult female.—Specimens mounted on slides, 1.91 to 3.11 mm. long, 1.55 to 3.11 mm. broad, very convex; derm membranous except along coria between segments, there irregularly chitinized on thorax and abdomen; antennæ reduced but not rudimentary, usually six-segmented, occasionally with four or five segments; setæ of basal segments short and stout, those of distal segments slenderer; tentorium and rostrum each about as broad as long, heavily chitinized; spiracles broad, heavily chitinized, with numerous multilocular disc pores and a few smaller, circular trilocular pores, in close proximity, legs reduced and poorly devloped but not rudimentary, claws very slender, without denticles, digitules hair-like; a pear-shaped portion of ventral derm—apparently a prolongation of each coxa—chitinized, slightly less than twice as long as rest of leg, and perforated with numerous small clear pores; dorsal surface with a few small stout setæ and numerous short, chitinized, tubular ducts, setæ most numerous along lateral margins and on posterior half of abdomen, with two pairs of small dorsal ostioles; setæ of ventral derm more numerous and larger, those of abdomen arranged in transverse rows segmentally, longest in region of vulva; multilocular disc pores, and short tubular ducts of dorsal type numerous, anal lobes very reduced, bearing on dorsal surface numerous setæ of type occurring on adjacent areas, some perhaps slightly larger, those of ventral surface slender, each anal lobe seta short; anal ring cellular, chitinized, broad, with six short setæ about size and length of anal setæ.

Host.—Apparently *Cyperus ovularis* or *echinatus*.

Locality.—A. and M. College, Mississippi: January 9, 10, 1929.

Dr. M. R. Smith, Collector.

Attended by or associated with ants: *Prenolepis* (*Nylanderia*) *parvula* Mayr.

This species is distinguished from any described species by the extremely large chitinized hind coxæ, bearing pores on their ventral surfaces, and by the irregular chitinization of the coriæ of thorax and abdomen. On a few specimens two or three of the dorsal setæ of the anal lobes were larger than the others, resembling cerarian spines. As this is not a constant condition, I have considered the cerarii as lacking.

The holotype is in the coccoid collection of the Mississippi State Plant Board; a paratype in the collection of Mr. E. E. Green.

Pseudantonina spirapuncta new species.

(Plate III, Figures 1–9.)

Sac.—Adult female enclosed in a white felted sac.

Adult female.—Specimens mounted on slides 1.38 to 1.71 mm. long, 1.00 to 1.38 mm. broad; derm apparently usually membranous except anal extremity; antenna small, six-segmented, attached near margin of head and about twice the width of a basal segment apart; eyes protruding slightly; tentorium slightly longer than broad, rostrum as broad as long, apparently two-segmented; spiracles conspicuous, peritremes densely chitinized with an irregular row of pores between lateral edge and spiracular opening; legs small, each hind leg with numerous large, indistinct, clear areas on femur and tibia, distal end of tibia much broader than adjacent end of tarsus; tibio-tarsal articulation distinct; claw slender, without denticle, ungual digitules enlarged at distal end, tarsal digitules hair-like; anterior dorsal ostioles apparently lacking, posterior pair small; ventral coriæ cephalad of second and of third abdominal segments with a conspicuous circular cicatrix heavily chitinized around edge, anterior one larger; dorsal and ventral derm with numerous multilocular pores, what appears to be trilocular pores and a few smaller pores, tubular ducts about same diameter as large pores, setæ stout, segmentally arranged, not numerous, lateral margins of posterior three or four abdominal segments with one to three long setæ; anal seta small, anal ring broad, heavily chitinized, densely cellular, six long anal ring setæ, anal setæ about one-half as long as anal ring setæ.

Host.—Grass roots.

Locality.—A. and M. College, Mississippi: November 28, 1927.

Collected by Dr. M. R. Smith and Mr. W. A. Douglass.

The species can be distinguished from *parrotti* by the absence of the grouped pores laterad of, though in close proximity to, the peritremes of the spiracles; by the presence of multilocular pores in the peritremes of the posterior pair of spiracles; by the larger legs which are well developed though small; and by the presence of two structures, apparently cicatrices, on the ventral meson, one between the first and second abdominal segments, and a smaller one between the second and third segments.

I am indebted to Mr. E. E. Green for calling my attention to the fact that this is a new species and not the same as *P. parrotti*. Some unmounted material was sent to Mr. Green as *P. parrotti* together with a mount of *parrotti*. Careful examination of the material in the collection reveals the fact that there are two lots of material bearing the same data, one lot being *parrotti*, the other *spirapuncta*. Although there was nothing on the labels to indicate that the material was not the same, Dr. Smith is of the opinion, and I agree with him, that if the two species had been collected in the same immediate vicinity the material would have been in one package and not in two.

The Holotype is in the coccoid collection of the Mississippi State Plant Board, and some of the material in the collection of Mr. E. E. Green.

Pseudococcus acutus new species.

(Plate IV, Figures 1–8.)

Living adult female.—Enclosed in a greenish white, resinous cell, usually about two to three mm. long and open at the distal end; posterior portion of the abdomen of living specimens protruding from the cell, its unusual pointed form being quite as distinctive in a living specimen as in a mounted one; the bands of large multilocular abdominal pores conspicuous on a mounted specimen, appear to be restricted to the portion of the abdomen which usually projects from the resinous cell. These cells were attached to the twig near the base of the needles.

Adult female.—Bodies of fourteen specimens mounted on slides measured 1.6 to 2.17 mm. long, .97 to 1.45 mm. broad; broadest through mesothorax, abdomen tapering sharply to posterior end, anterior end of body rounded; surface of body powdered with fine white wax; derm membranous; antennæ seven-segmented, distal longest; tentorium and legs of average sizes, each posterior tibia usually slightly more than twice as long as tarsus, tibia scattered with a few clear pores; spiracles small; anterior and posterior dorsal ostioles present; trilocular pores

scattered on dorsal and ventral surface; ventral surface of head and thorax with a few scattered multilocular disc pores, margins of ventral surface of first two or three abdominal segments with a few pores, each remaining segment of abdomen with transverse row of pores along caudal margin extending onto dorsal surface and forming a continuous band except on third and possibly on fourth segment, a few ducts on abdomen; margins of abdominal segments bearing cerarii consisting of a few trilocular pores and two small cerarian spines, anal cerarii with about eight pores, preceding segments with successively fewer pores; cerarian spines possibly occurring on thorax and head but apparaently lacking; dorsal and ventral surfaces with scattered setæ, most abundant on posterior half of abdomen; anal lobes much reduced, anal setæ slightly longer than ventral pair of anal ring setæ, median pair of anal ring setæ shortest, dorsal pair slightly longer than median; anal ring large, dorsally located.

Host.—Pine twigs (*Pinus* sp.).

Locality.—Ocean Springs, Mississippi; March 28, 1927.

Mr. J. P. Kislanko, Collector. S. R. No. 4681.

This species can be distinguished from any species I know by the relatively large multilocular disc pores on the dorsal as well as the ventral surface of the abdomen, the small ducts, and the relatively inconspicuous cerarii.

Specimens of a species, which, with the exception of a normally shaped abdomen instead of a pointed one and an absence of a resinous cell, is very similar to if not the same as *acutus* were collected by Mr. J. M. Langston under flakes of bark of a pine on the Horticultural Department Grounds, A. and M. College, Mississippi, August 3, 1927. These were attended by ants.

The types are in the coccoid collection of the Mississippi State Plant Board.

Pseudococcus dentatus new species.

(Plate V, Figures 1–5.)

Adult female.—Body mounted on slide 1.65 to 2.40 mm. long, .95 to 1.45 mm. broad; derm membranous; antennæ eight or seven-segmented; legs of average size, hind coxæ with numerous rather large clear areas, trochanters, femora, tibiæ, tarsi, and each segment of fore and midlegs with few indistinct clear areas, tibiæ with two large, heavy spines, claws frequently with a small but definite denticle; spiracles of usual type; rostrum about three-fourths as broad as long; derm scattered with trilocular pores and setæ, setæ of dorsal surface short, not numerous, arranged in transverse rows, ventral setæ longer especially on meson; a few large tubular ducts with chitinized raised rims around mouth on lateral and dorsal surface apparently segmentally arranged; lateral

margins of segments with clusters of small tubular ducts, most numerous on posterior abdominal segments and on head; ventral surface of abdomen with numerous large multilocular disc pores, abdomen usually with five to seven pairs of cerarii consisting of two slender cerarian spines and about four trilocular pores, pores and setæ reduced towards thorax, pores more numerous and setæ larger on anal lobes and derm apparently slightly chitinized with two or three slender accessory setæ, ventral surface with three short setæ, a slight chitinized bar extending cephalad from each anal seta, anal setæ slightly longer than anal ring setæ, one specimen with fourth pair of small anal ring setæ located in close proximity to ventral pair, anal ring of usual Pseudococcine type with a single row of outer cells between first and third pairs of setæ.

Host.—Ragweed (*Ambrosia* sp.) roots.

Locality.—A. and M. College, Mississippi: November 28, 1927.

Collected by Dr. M. R. Smith.

Attended by ants (*Pheidole vinelandica* Forel).

This species differs from any other that I know in usually having a denticle on the claws, tubular ducts with chitinized raised rims around the mouths, and with cerarii restricted to the abdomen.

The types are in the coccoid collection of the State Plant Board.

Pseudococcus difficilis new species.

(Plate VI, Figures 1-9.)

Living specimens.—Entire body covered with fine white, powdery wax, in rubbed specimens, derm showing through as light brown in color; largest specimen examined 2.6 mm. long, 2 mm. broad, smallest specimens 2 mm. long; segmentation distinct; eight or nine wax pencils projecting from abdominal segments, increasing in size toward anal lobes; longest pencil .4 mm., two pairs on head, apparently none on thorax; two short flat wax plates protruding from lateral and ventral half of anal ring apparently united on ventral surface, one specimen with a drop of light amber-colored fluid above left posterior ostiole, fluid quickly volatile when surface film was punctured, or quickly absorbed by bark on which specimen rested.

Larva.—Body of specimen examined .56 mm. long, derm membranous; antennæ large, six-segmented; legs large, claws without denticle; spiracerores apparently lacking, two pairs of dorsal ostioles, large; dorsal and ventral surfaces with trilocular pores; one pair of cerarii, on anal lobe, bearing two long stiff spines and cerores placed close together; six anal ring setæ apparently longer than anal lobe setæ.

Adult female.—Specimens mounted on slide slightly longer than broad, 2.1 to 2.6 mm. long, 1.8 mm. broad; derm thin and membranous; antennæ eight-segmented, distal segment longest; legs of average size,

posterior aspect of hind femur and of tibia with numerous clear areas or pores, tibia 2.5 to 3 times as long as tarsus, claw without denticles; trilocular pores on dorsal and ventral surface; circular pores on ventral surface of abdomen more numerous near vulva, small tubular ducts on ventral surface; spines not constricted at base, long and slender, especially on ventral surface; six anal ring setæ, anal lobe seta usually same length as anal ring setæ; ventral surface of anal lobes with large chitinized area bearing several short and one or two long setæ; apparently ten to twelve pairs of cerarii, exact number difficult to determine, usually two pairs on head and eight or nine pairs extending cephalad from anal lobes, cerarian spines range in size from small to large, exact number of each size difficult to determine, first pair of cerarii usually with 4 to 5 long and 2 to 4 short spines; second pair with 4 long and 5 short spines, occasionally a single large spine that apparently represents third pair; fourth pair, 1 to 2 when present; fifth pair, 1 to 3 long, 1 to 3 short; sixth, 0 to 4 long, 1 to 5 short; seventh, 1 to 4 long, 3 to 6 short; eighth, 1 to 4 long, 4 to 7 short; ninth, 2 to 3 long, 3 to 8 short; tenth, 2 to 3 long, 3 to 9 short; eleventh, 2 long, 5 to 14 short; twelfth, or anal lobe pair, 2 to 3 long, 1 to 4 short; cerarii with about 0 to 4 accessory setæ and with grouped triangular pores numerous, about 9 in fifth pair and increasing toward anal lobe cerarii where they number about 100; last six or seven pairs of cerarii usually with derm more or less chitinized.

Host.—Ash. (*Fraxinus* sp.). Most abundant near scarred places on trunk.

Locality.—In front of Biology Building, A. and M. College, Mississippi: August 28, 1926.

Collected by Mr. J. M. Langston.

Description of larva and of living adult females are from specimens taken in crevices of bark of ash, Mayhew, Mississippi, November 11, 1926, by Dr. M. R. Smith. These specimens were attended by Argentine ants (*Iridomyrmex humilis*, Mayr.). Specimens at A. and M. College were attended by fire ants (*Solenopsis geminata* Fabr.).

Dr. Harold Morrison says, "I have not succeeded in associating this with any species in the collection, nor do described species seem at all closely related."

The types are in the coccoid collection of the Mississippi State Plant Board.

Pseudococcus obesus new species.

(Plate VII, Figures 1–4.)

Unmounted adult female.—Living specimens plump, measuring 3.28 to 4.38 mm. long, 2.20 to 2.92 mm. broad, 1.80 mm. high; covered with fine white, powdery wax, easily rubbed off, showing through as reddish

flesh color, segmentation distinct; white waxy marginal pencils small, a pair on anterior end, usually two on sides of thorax and nine consecutive pairs on posterior half of body.

Adult female.—Body mounted on slide 3.02 to 4.19 mm. long, 2.00 to 3.20 mm. broad; derm membranous, antennæ eight-segmented; legs stout, hind tibiæ slightly more than twice as long as tarsi and with numerous rather large clear areas, coxæ and femora without clear areas; spiracles with a few pores; rostrum about two-thirds as long as tentorium, latter about four-fifths as broad as long; two pairs of dorsal ostioles; derm with numerous trilocular pores and small setæ, setæ longest on posterior end of abdomen, ventral surface of abdomen near vulva with numerous multilocular disc pores and small tubular ducts; each cerarius consisting of short cerarian spines, long slender accessory setæ, and numerous trilocular pores usually less than their own width apart, cerarii of fourteen specimens examined, arranged: one on head, three on thorax, and eight on abdomen; nine specimens showed one to two smaller cerarii, paired in only one instance, these being between last two thoracic groups, variation as follows:

	Head			Thorax			
C. S.	2– 5	0–1	1– 4	0–0 to 2	1– 4	0–2	1– 4
A. S.	0– 4	0–2 to 3	1– 5	0–0 to 3	1– 5	0–2 to 3	1– 3
P.	23–42	0–1 to 7	28–35	0–3 to 9	28–35	0–8 or 36	9 or 18–43

			Abdomen				
1– 4	2– 5	2– 6	3– 7	3– 6	2– 5	2– 6	2–2 or 3
1– 5	0– 6	0– 5	0– 4	0– 4	0– 3	0– 4	4–6
15–50	26–44	25–48	37–54	33–57	32–53	50–60	95–117

Anal lobes not well developed, dorsal surface without chitinization, ventral surface bearing a long anal seta and about ten shorter slenderer setæ and a small slightly chitinized area cephalad of shorter setæ; anal ring setæ two-thirds as long as anal setæ.

Host.—Pine (*Pinus* sp.) trunk, under flakes of bark or around scarred places.

Locality.—Meridian, Mississippi: November 14 and 23, 1927. Collected by Dr. M. R. Smith.

Attended by Argentine ants (*Iridomyrmex humilis* Mayr.)

This species is very similar to *P. morrisoni*, but apparently differs from it in having only a few clear areas on the hind femora, these sometimes apparently lacking, in having a much larger number of trilocular pores (usually more than thirty) associated with each cerarius; and in having only a very small, slightly chitinized area on the cephalic end of the ventral surface of the anal lobes.

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection and in the collection of the U. S. National Museum.

Trionymus claviseta new species.

(Plate VIII, Figures 1–5, and Plate IX, Figures 1–8.)

Adult female.—Bodies of specimens containing embryonic larvæ 1.98 to 2.31 mm. long, 1.32 to 1.58 mm. broad; derm membranous; antennæ seven-segmented, third or fourth segment usually with more or less indication of division; legs of usual type, front tibia 1.3 to 1.9 times as long as tarsus, hind tibia 1.7 to 2.0 times as long as tarsus, hind coxa with a few small translucent pores, latero-ventral spines on distal end of tibia small; tentorium broad, well developed, rostrum two-segmented; spiracles apparently without grouped pores; derm with numerous setæ, those of dorsal surface often slightly enlarged at tip, apparently never tapering to a fine point as do those of the ventral surface, segmentally arranged on abdomen; numerous trilocular pores on dorsal and on ventral surfaces, ventral surface with large multilocular pores on abdomen near vulva, a very few small multilocular (?) pores on ventral surface of body; a few small tubular ducts on ventral surface; dorsal surface occasionally with a large tubular duct opening to the surface through a pore with a chitinized rim and with about three to five small setæ in close proximity; posterior end of abdomen with three or four or possibly occasionally more of the same type, position and number variable; cerarii lacking except anal lobe pair, each with two large spines on a slightly chitinized area with about six or seven slender accessory setæ, ventral surface of anal lobe with a small chitinized area bearing one or two medium sized setæ, laterad of it three or four similar setæ, one long anal lobe seta; anal ring of usual *Pseudococcine* type, with usually six setæ, one specimen with seven, anal ring setæ two-thirds as long as anal lobe setæ.

Host.—Hackberry (*Celtis mississippiensis* Bosc.) bark.

Locality.—Mayhew, Mississippi: November 12, 1926. Collected by Dr. M. R. Smith.

Attended by ants (*Crematogaster* sp.).

The distinguishing characteristics of this species are: the bluntly pointed or slightly clavate dorsal setæ, a small chitinized area on the ventral surface of each anal lobe, and a single pair of cerarii, these located on the anal lobes, consisting of two large spines each.

The holotype and paratype are in the coccoid collection of the Mississippi State Plant Board.

Trionymus mori new species.

(Plate X, Figures 1–7.)

Adult female.—Body mounted on slide 1.98 to 2.18 mm. long, 1.18 to 1.22 mm. broad, derm membranous; antennæ eight-segmented; legs of normal size, hind coxa with numerous clear areas or pores on lateral aspect; femur with rather stout setæ, tibia with a few pores,

claw without denticles, digitules well developed; tentorium as broad as long, rostrum about five-eighths as broad as long, two-segmented; spiracles slender without grouped pores; setæ not numerous; trilocular pores on dorsal and ventral surfaces, a few multilocular pores on head and on ventral surface of abdomen, most abundant near vulva, small tubular ducts most abundant on lateral margins of segments, most numerous on head and abdomen, extending in transverse rows across ventral surface of abdomen; large tubular ducts not numerous but usually with one or more occurring on lateral margins and on dorsal surface of each segment; three dorsal to each segment except first three, sixth, and last three, cerarii restricted to abdomen, number of pairs varying, usually two or three posterior pairs recognizable or sometimes with as many as six on one side, anterior pairs recognizable chiefly by the position of the two cerarian spines which become more seta-like anteriorly; derm around base of the two spines of the anal lobe cerarii chitinized, bearing a few trilocular pores and two or three slender accessory setæ; a chitinized bar extending cephalad from each long anal lobe seta; anal ring setæ about three-fourths as long as anal lobe setæ.

Host.—Mulberry (*Morus* sp.).

Locality.—West Main Street, West Point, Mississippi (Property of B. L. Meyers): July 7, 1928. Collected by Mr. G. L. Bond.

This species can be distinguished from *Trionymus shaferi* (Hollinger , 1923) by the presence of a chitinized bar on the ventral surface of each anal lobe and by the chitinization of the derm of the anal cerarii.

The types are in the coccoid collection of the Mississippi State Plant Board.

Trionymus rostellum new species.

(Plate XI, Figures 1-7.)

Adult female.—Bodies of 16 mounted specimens varying from 2.24 to 3.70 mm. long, 1.02 to 1.72 mm. broad; derm membranous; antennæ eight-segmented; legs of usual type, slender, hind coxæ of usual shape and with clear pores rather numerous, setæ stout, tibia twice as long as tarsus; tentorium small, seven-eighths as broad as long, rostrum two-segmented, short, as broad as long, one-half as long as tentorium, bearing fourteen pairs of setæ, four pairs on ventral surface of proximal segment and seven pairs on ventral surface and three on dorsal surface of distal segment; spiracles small about twice as long as broad with few if any grouped pores; anterior and posterior dorsal ostioles small; setæ not numerous; segmentally arranged; trilocular pores fairly numerous on both dorsal and ventral surfaces, multilocular pores on ventral surface of last five abdominal segments with a few on the third and on thorax between anterior leg and spiracle, apparently never any on the head;

a small circular ventral cicatrix between third and fourth abdominal segments; tubular ducts of two sizes, small and medium size, not numerous, a few medium sized ones on head and along margins, small ones segmentally arranged, most abundant on posterior half of ventral surface of abdomen, cerarii lacking except on anal lobes, each consisting of two stout spines with about six associated pores; ventral surface of anal lobe without chitinization, with one long anal seta; 6 anal ring setæ about five-ninths as long as anal seta.

Host.—Crab grass (?), nut grass.

Locality.—Near hospital, Houston, Mississippi: October 23, 1929.

Collected by Dr. M. R. Smith.

This species was also collected by Dr. Smith on wire grass (*Elusina indica*) at Eupora, October 19, 1929. These specimens were quite abundant on the grass between the leaf sheath and the stem and crawling on the surface of the ground. Some of the females contained eggs. This species differs from *shaferi*, with which it might be confused, by the absence of a conspicuous, or enlarged, shoulder on hind coxæ; by the absence of multilocular pores on the head; by the presence of a small group of multilocular pores on the ventral surface between the anterior leg and spiracle; and by the much shorter rostrum. In this species the rostrum is one-half as long as the tentorium while in *shaferi* it is approximately the same length.

The holotype and paratypes are in the coccoid collection of the Mississippi State Plant Board.

Trionymus setosus new species.

(Plate XII, Figures 1–5, and Plate XIII, Figures 1–5.)

Living adult female.—Thickly covered with fine, white, powdery wax.

Larva.—Body mounted on slide .53 mm. long, .27 mm. broad; antennæ six-segmented; each tibia four-fifths as long as tarsus, claw without denticle, anal lobe bearing a cerarius with two cerarian spines, no accessory setæ, posterior dorsal ostioles distinct, six anal ring setæ, slightly more than one-half as long as anal lobe setæ; triangular pores and setæ arranged in transverse rows on abdominal segments.

Immature female.—Body mounted on slide 1.45 mm. long, .85 mm. broad; antennæ six-segmented; legs stout, coxa and femur broad, tibia slightly longer than tarsus, claw without denticle; spiracles medium or small in size; derm membranous, dorsal and ventral surfaces with triangular pores and slender setæ; large tubular ducts opening on dorsal surface through pores of multilocular type as in figure, with chitinized rims and usually with about two long, curved accessory setæ; specimens examined with ten or eleven on one margin and with

thirteen on the other, apparently lacking on anal lobes but with two on preceding segment, apparently one on meson of meso- and meta-thorax and of each of two segments cephalad of posterior dorsal ostioles, possibly others; setæ of dorsal surface with blunted tips, those of ventral surface pointed; only one pair of cerarii, these on anal lobes, with two long conical spines, about two accessory setæ, and a few trilocular pores; ventral surface of lobe with one long and two short setæ; anal ring cellular, of usual Pseudococcine type; anal ring setæ slightly more than one-half as long as anal lobe setæ.

Adult female.—Specimens mounted on slide about 3.7 to 4.2 mm. long, 1.9 to 2.3 mm. broad; derm membranous; antenna eight-segmented, distal segment longest, basal segment long and only slightly broader than second segment; legs of usual Pseudococcine type, claw without denticle; spiracles medium large; derm with numerous trilocular pores and long setæ; posterior dorsal ostioles large; margin with about fifteen pairs of tubular ducts, number apparently variable, opening through pore with chitinized rim, usually with about four accessory setæ; a few ducts of same type on dorsum of thorax and abdomen; anal lobe slightly chitinized; usually with two or four long cerarian spines, about two accessory setæ, and numerous trilocular pores, other cerarii lacking, margins of third and fourth abdominal segments cephalad of anal lobes apparently with clusters of setæ which extend onto dorsal surface toward meson, clusters decreasing in size cephalad; anal ring setæ apparently variable in number, ranging in specimens observed from twelve to thirty-six, typically with three pairs of long setæ as in typical Pseudococcine forms and with a variable number of smaller setæ located between larger ones, smaller setæ about one-half as long as large ones, large ones about one-half as long as longest anal seta; anal ring with single outer row of cells extending from cephalic pair of setæ ventrad to near last pair of large setæ; ventral surface near vulva with numerous setæ about same length as anal ring setæ.

Host.—Sweet gum (*Liquidambar styraciflua* L.) near roots in "cowsheds" built by ants.

Locality.—Durant, Mississippi: September 18, 1926. Collected by Mr. G. R. Williams.

The specimens were attended by ants which had built "cowsheds" over them. The descriptions of the larva and the adult female were made from material collected September 28. The immature female was kept on sweet gum at A. and M. College, until October 26, when the mount was made.

This species differs from any described species with which it might be confused in the large number of anal ring setæ.

Attended by Argentine ants (*Iridomyrmex humilis* Mayr.).

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection and in the collection of the U. S. National Museum.

Trionymus varus new species.

(Plate XIV, Figures 1–5.)

Embryonic larva.—Antennæ six-segmented, one pair of cerarii, on anal lobes, consisting of two cerarian setæ; anal ring setæ about five-ninths as long as anal lobe setæ.

Third (?) stage female.—Body 1.38 mm. long, antennæ seven-segmented, legs stout, posterior coxæ with clear areas; setæ and pores of dorsal and ventral surface and of cerarii fewer than in adult; otherwise very similar to next stage.

Adult female.—Body of specimens mounted on slide 2.78 mm. to 3.20 mm. long, 1.90 to 2.40 mm. broad; derm membranous; antennæ eight-segmented, distal segment longest; legs short and stout, hind coxæ with small clear circular areas on lateral side, tibiæ with a few clear areas near distal end on outer edge, tarsi about three-fifths as long as tibiæ, digitules slightly longer than claw, spiracles broad; tentorium small but stout, rostrum two-segmented, large, longer than tentorium; dorsal derm with numerous small trilocular pores and small setæ, ventral derm with similar but fewer pores and longer setæ; lateral margins with small clusters of clear irregular-shaped areas segmentally arranged, ventral derm adjacent to vulva with multilocular disc pores and with small tubular ducts along last four coriæ; cerarii restricted to anal lobes, each consisting of two slender cerarian spines with about seventeen long flexible accessory setæ, numerous trilocular pores and about an equal number of less distinguished quinquelocular (?) pores or pore-like structures of different sizes; ventral surface of lobes with one long and numerous shorter setæ; anal ring with six setæ of approximately same size, frequently with a seventh small accessory seta between dorsal and median setæ on one side; anal ring setæ about two-thirds as long as anal setæ; ovoviviparous.

Host.—Oak (*Quercus* sp.).

Locality.—West Point, Mississippi: August 30, 1927. Collected by Dr. M. R. Smith. The description of the third (?) stage female is of a specimen which Dr. Smith collected on oak at Adaton, April 5, 1927. There is present in this material one young adult female which measures 2.1 mm. in length. All the other specimens collected at this time are immature.

This species is apparently closely related to *jessica* but it differs from that species in possessing distinct anal lobe cerarian spines and larger anal lobe setæ.

The holotype and paratypes are in the coccoid collection of the Mississippi State Plant Board.

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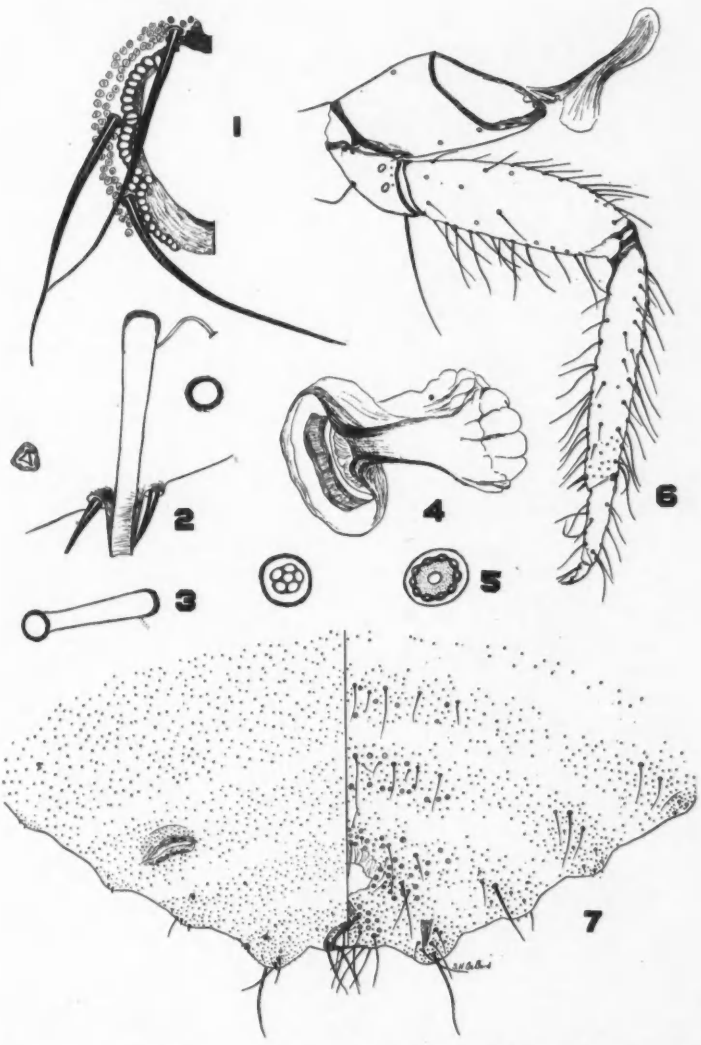
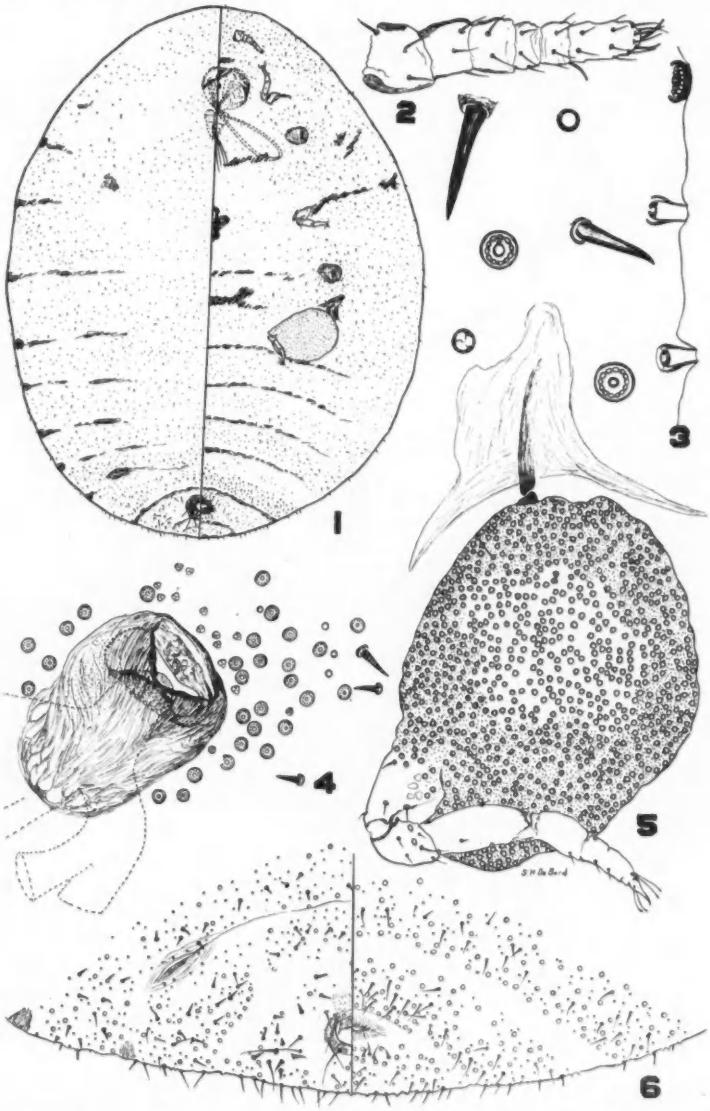
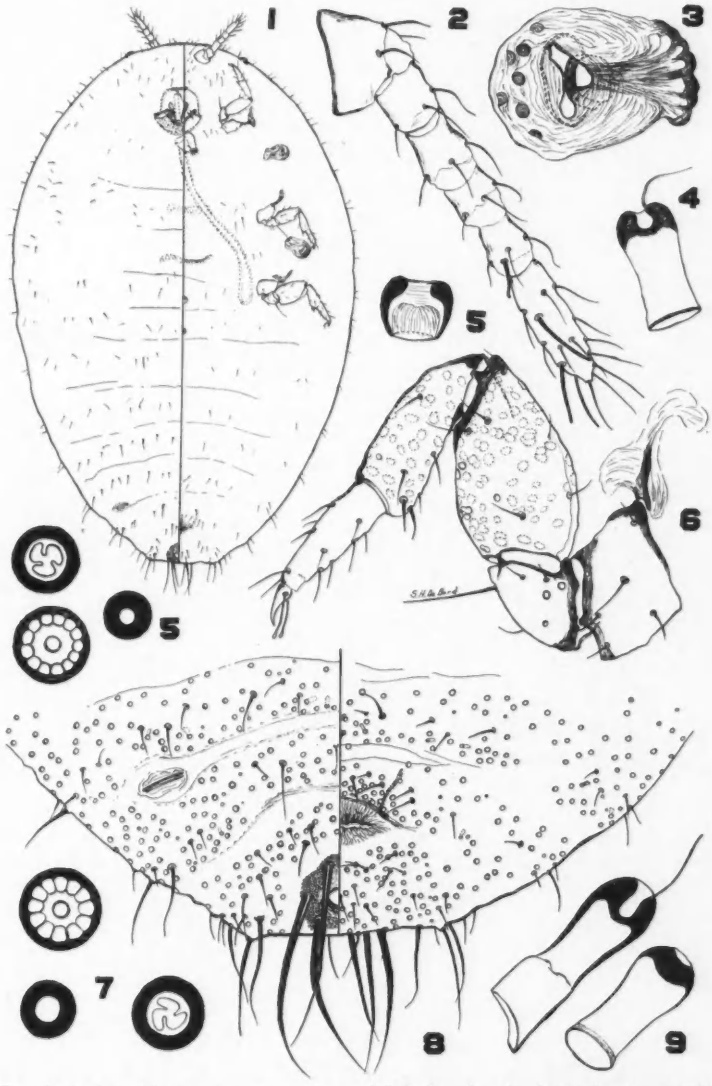
(6) California Species of Mealybugs, Leland Stanford Junior University Publications, 1918.



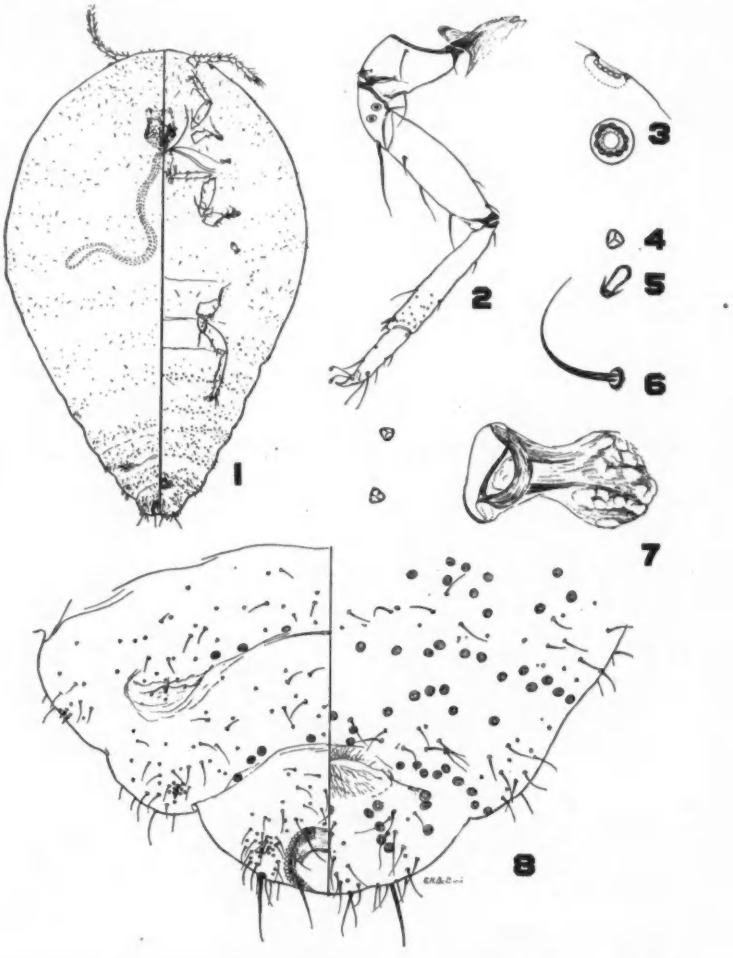
Phenacoccus insignis, new species. Adult female. 1, Anal ring × 350. 2, Duct and trilocular pore from dorsal surface, × 1100. 3, Duct, ventral surface, × 1100. 4, Anterior spiracle, × 350. 5, Pores, ventral surface near vulva, × 1100. 6, Hind leg, × 118. 7, Posterior end of abdomen, × 69.



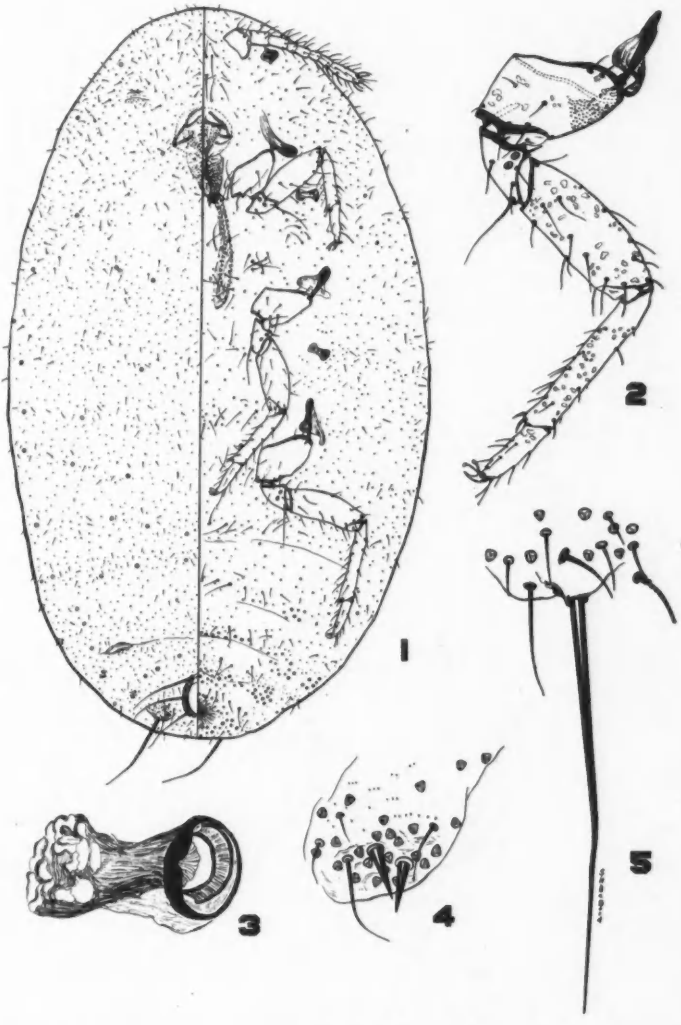
Pseudantonina giganticoxa new species. Adult female. 1, Adult female, × 41. 2, Antenna, × 290. 3, Setæ, pores, ducts, × 875. 4, Posterior spiracle, × 290. 5, Left hind leg, × 290. 6, Posterior abdominal segments, × 94.



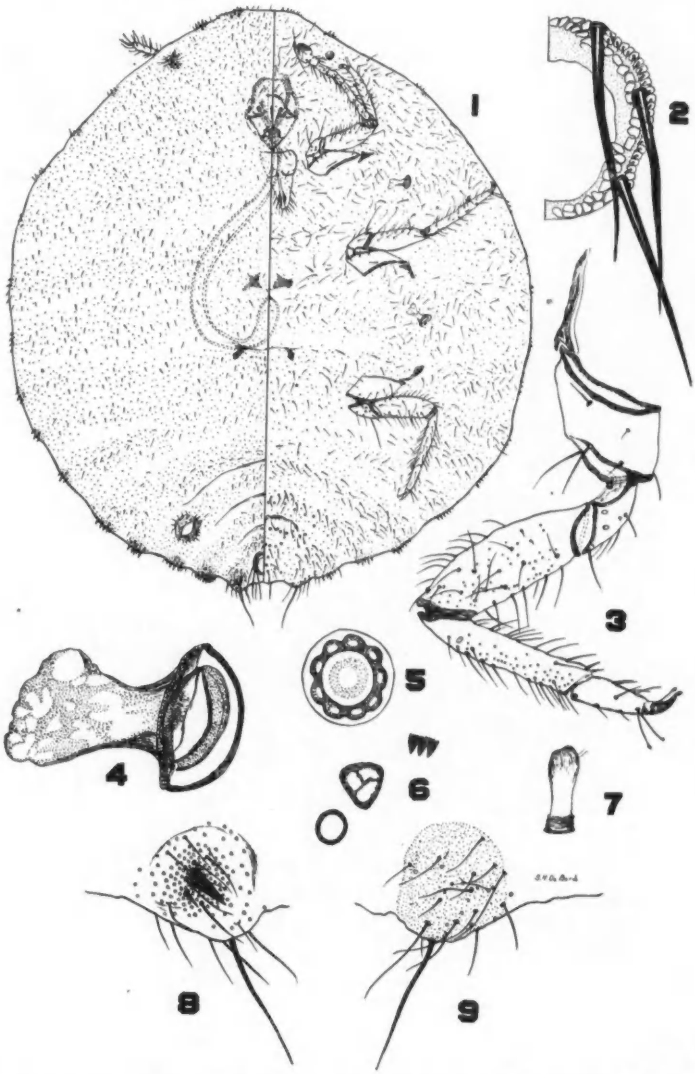
Pseudantonina spirapuncta new species. Adult female. 1, Adult female, × 46. 2, Antenna, × 400. 3, Spiracle, posterior, × 400. 4, Duct of ventral surface, × 1750. 5, Pores of ventral surface, × 1750. 6, Hind leg, × 290. 7, Pores of dorsal surface, × 1750. 8, Posterior end of abdomen, × 152. 9, Ducts of dorsal surface, × 1750.



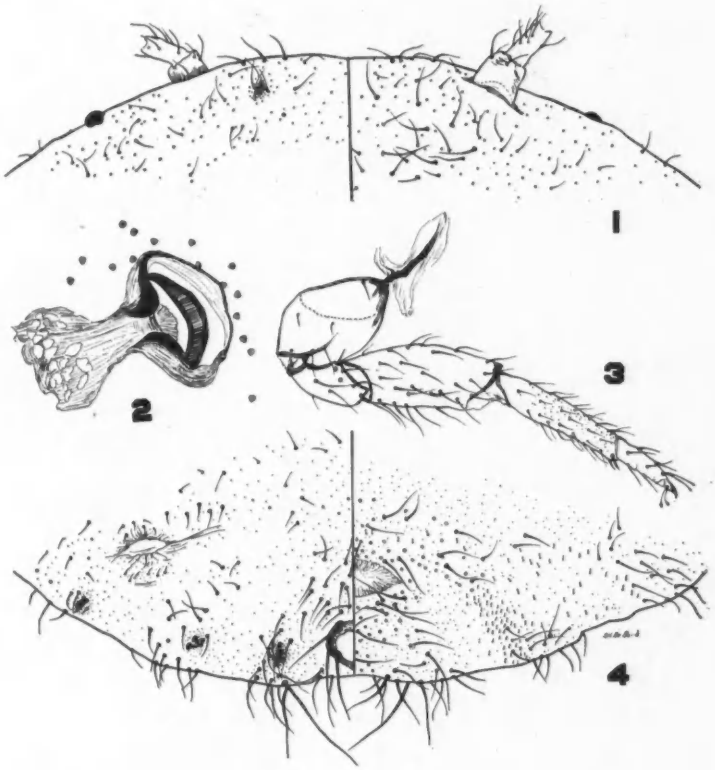
Pseudococcus acutus new species. Adult female. 1, Adult female, × 34. 2, Hind leg, × 152. 3, Pore, × 875. 4, Trilocular pore, × 875. 5, Duct, × 875. 6, Seta, × 875. 7, Posterior spiracle and pores, × 225. 8, Posterior end of abdomen, × 187.



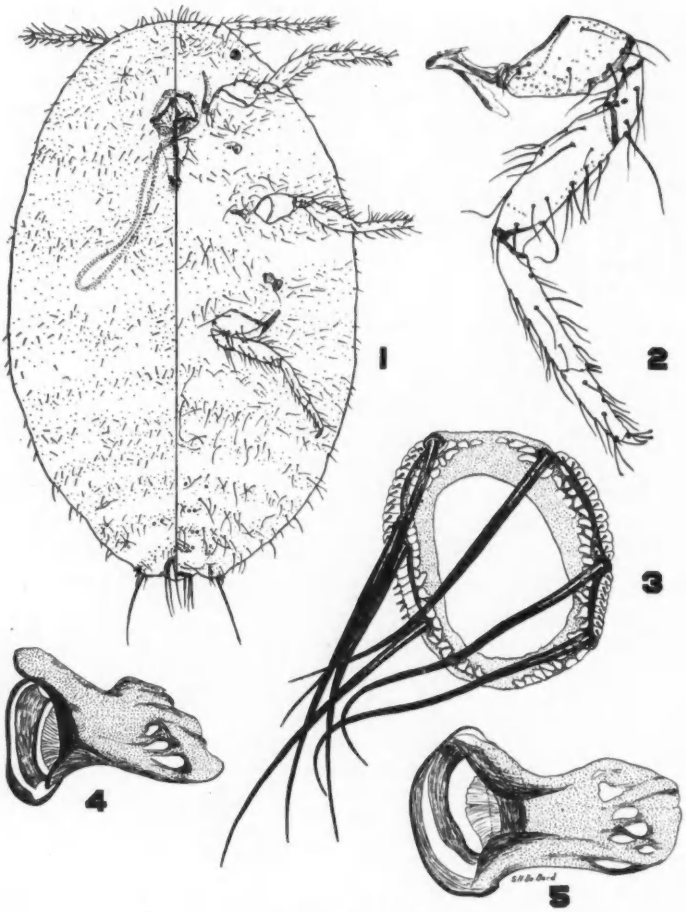
Pseudococcus dentatus new species. Adult female. 1, Adult female, × 68. 2, Posterior leg, × 152. 3, Posterior spiracle, × 725. 4, Anal lobe, dorsal × 400. 5, Anal lobe ventral, × 400.



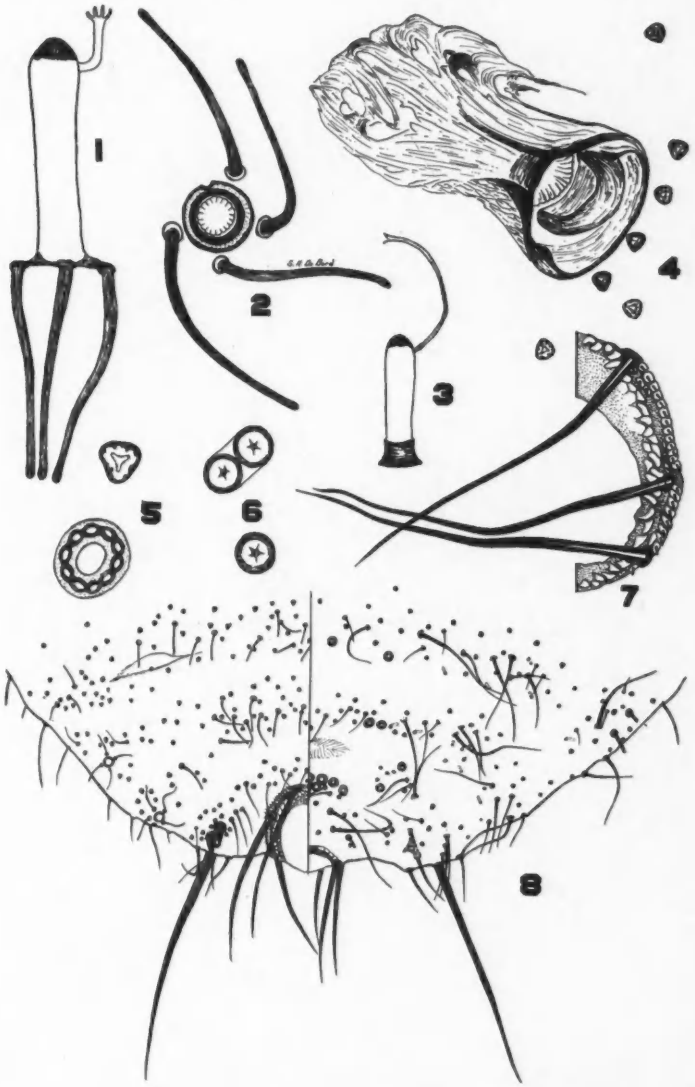
Pseudococcus difficilis new species. Adult female. 1, Adult female, × 40. 2, Anal ring, × 350. 3, Hind leg, × 118. 4, Anterior spiracle, × 350. 5, Multilocular pore of ventral surface, greatly enlarged. 6, Trilocular pore and markings of derm, greatly enlarged. 7, Duct, greatly enlarged. 8, Anal lobe, dorsal aspect, × 203. 9, Anal lobe, ventral aspect, × 203.



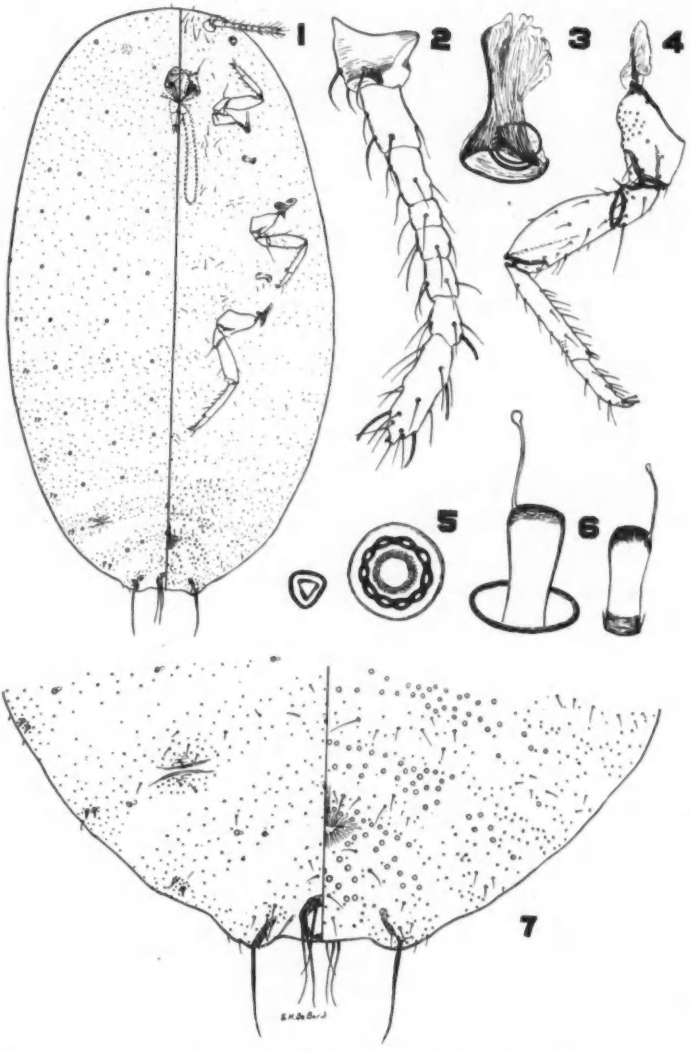
Pseudococcus obesus new species. Adult female. 1, Anterior end of head, × 68. 2, Posterior spiracle and pores, × 290. 3, Hind leg, × 94. 4, Posterior end of abdomen, × 68.



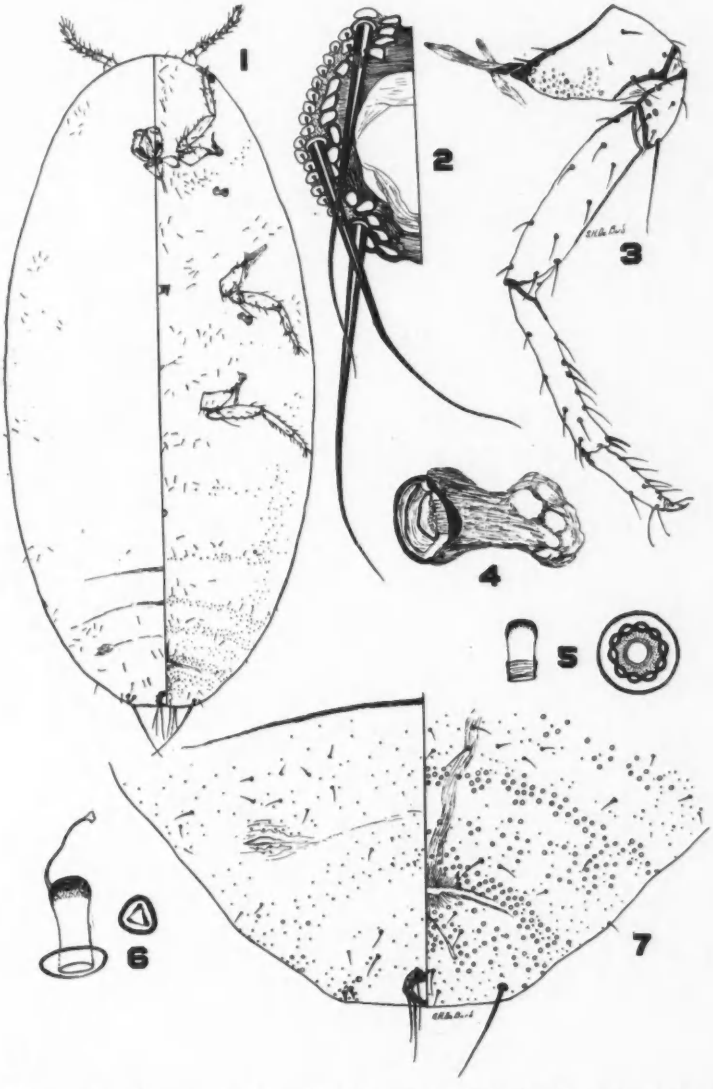
Trionymus claviseta new species. Adult female. (see also plate IX) 1, Adult female, × 39. 2, Hind leg, × 118. 3, Anal ring, × 350. 4, Anterior spiracle, × 471. 5, Posterior spiracle, × 471.



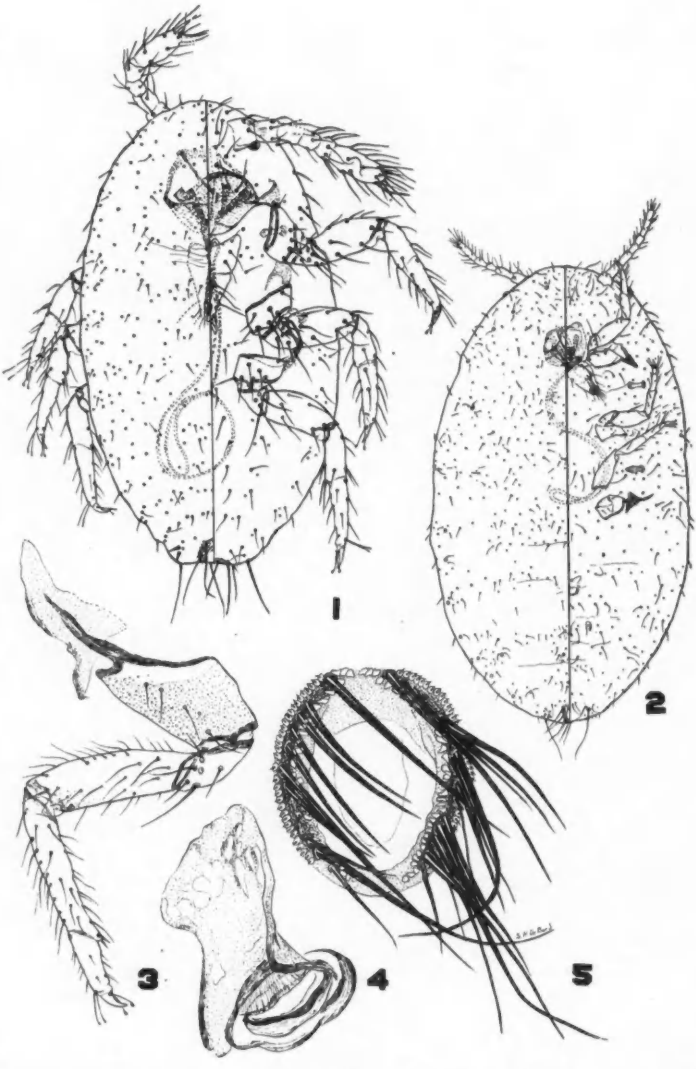
Trionymus claviseta new species. Adult female. 1, Duct, side aspect, × 1500? 2, Duct, surface aspect, × 1500? 3, Small duct of ventral surface, × 1500? 4, Posterior spiracle and pores, × 750. 5, Pores, × 1500? 6, Pores, × 1500? 7, Anal ring, × 350. 8, Posterior end of abdomen, × 141.



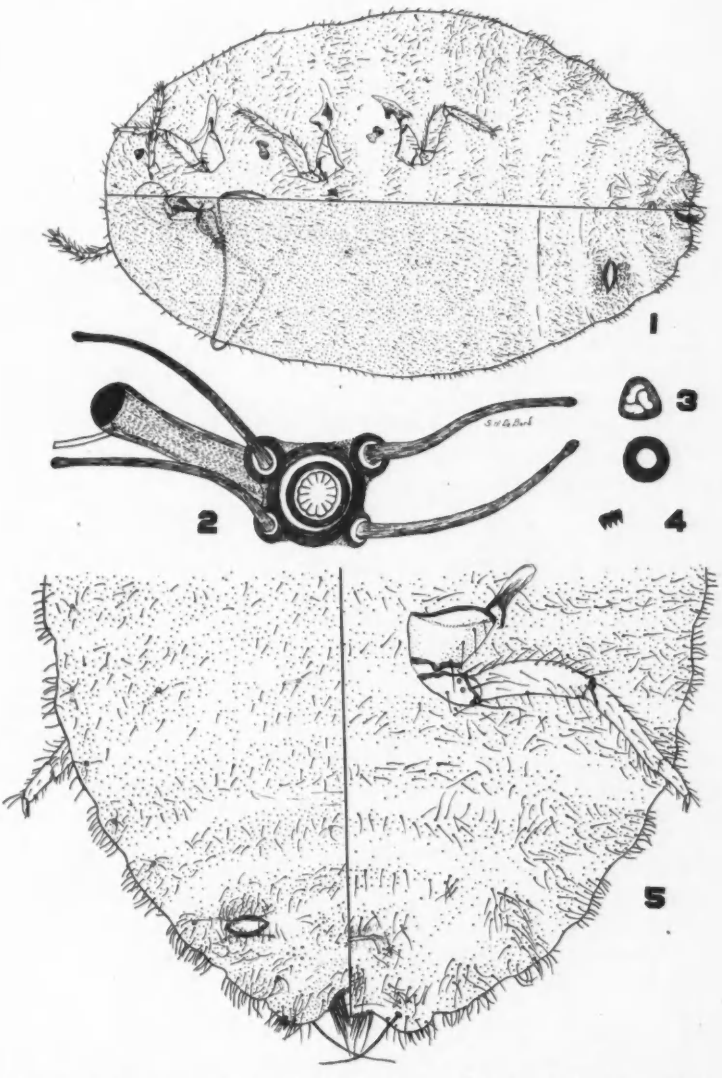
Trionymus mori new species. Adult female. 1, Adult female, × 42. 2, Antenna, × 465. 3, Spiracle, posterior, × 465. 4, Hind leg, × 240. 5, Pores, × 1750. 6, Ducts, × 1750. 7, Posterior end of abdomen, × 109.



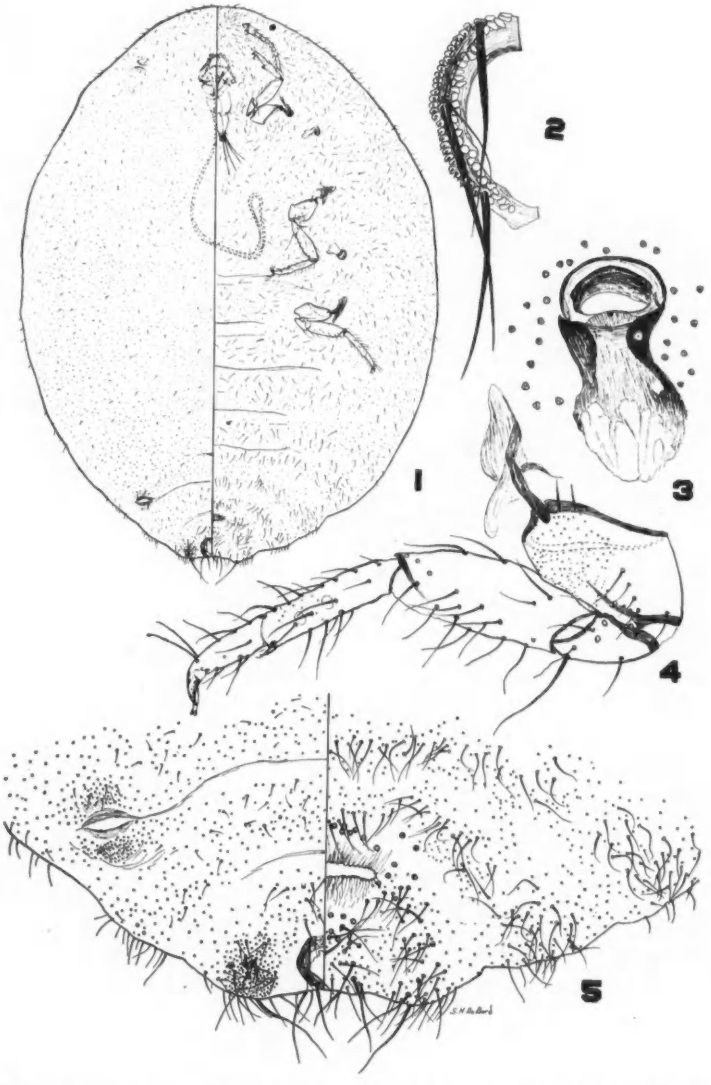
Trionymus rostellum new species. Adult female. 1, Adult female, × 80. 2, Anal ring, × 725. 3, Hind leg, × 187. 4, Posterior spiracle, × 465. 5, Duct and pore of ventral surface, × 1750. 6, Duct and pore of dorsal surface, × 1750. 7, Posterior end of abdomen, × 109.



Trionymus setosus new species. Immature. 1, Newly hatched larva, × 118. 2, Second stage, (?), × 48. Adult female. 3, Hind leg, × 76. 4, Anterior spiracle, × 290. 5, Anal ring, × 290.



Trionymus setosus new species. Adult female. 1, Adult female, × 22. 2, Duct, × 972 (?). 3, Trilocular pore, greatly enlarged. 4, Markings of ventral derm, greatly enlarged. 5, Hind leg and abdomen, × 58.



Trionymus varus new species. Adult female. 1, Adult female, × 27. 2, Anal ring, greatly enlarged. 3, Posterior spiracle, × 290. 4, Hind leg, × 152. 5, Posterior end of abdomen, × 77.

THE PLEURAL AND STERNAL SCLERITES OF THE LEPIDOPTEROUS THORAX.*

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INTRODUCTION.

Some excellent studies have been made by various workers on the morphology of the sclerites of the thorax of insects. Few of these, however, have dealt with the thoracic sclerites of Lepidoptera. Many of the figures of the thorax of Lepidoptera that may be found in our present literature are either very unsatisfactory drawings or are merely included in a general study of all orders of insects with respect to the morphology of this body-region. No American investigator up to now has devoted much study to the different types of development in the lepidopterous thorax.

Because of the evident value of a study of the thoracic sclerites in determining the phylogenetic relationships of the families of insects, this study has been undertaken. In the Lepidoptera there is a somewhat customary linear arrangement of families. When any attempt has been made to derive a phylogenetic tree to show which families are the more primitive and generalized, and which the more specialized, and to show how close the more primitive families may be to the ancient lines of development of which the higher families are the result, there has been considerable disagreement amongst the various arrangements which have been published. A discussion of phylogeny, it seems to the author, should be based upon a careful comparison of many species in each family, in order that there may be no conclusion based upon aberrant forms. Owing to a great lack of information only a few general conclusions concerning phylogenetic relations in the Lepidoptera may be pointed out at this time. At a later date it is hoped

* This paper is offered as a thesis in partial fulfillment of the requirements for the Degree of Doctor of Philosophy at the Massachusetts Agricultural College. The author is indebted to Dr. G. C. Crampton for his suggestion of the subject and for his helpful interest and encouragement, and to Dr. H. T. Fernald for his kind assistance in securing specimens from various sources. He also wishes to express his appreciation of much useful criticism by Mr. R. E. Snodgrass, of the U. S. Bureau of Entomology.

that further study will have gained for us sufficient material to formulate, in conjunction with phylogenetic evidence from the other useful characters, a general family relationship in the Lepidoptera.

GENERAL TERMINOLOGY.

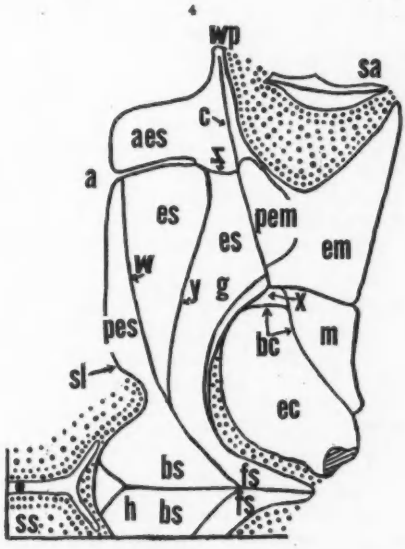
In this discussion two forms will be employed for illustration, namely, *Melittia satyriniformis* Hbn. (Aegeriidæ) (Fig. 1) and *Catocala concumbens* Wlk. (Noctuidæ) (Fig. 2). It is not claimed that the former species is particularly primitive in many respects. The species is used here because it shows in the one insect most features of the pleural region which occur in part in many of the higher families of Lepidoptera. *Catocala concumbens* is representative of the latter. The figure in the text may be referred to for the general relationships of the various features of the lepidopterous mesopleuron and sternum.

The terminology used is that adopted by most of the recent writers on general morphology of the thorax, such as Crampton (1909–1926), Snodgrass (1909–1927), Young (1921), etc. However, certain characteristic sutures and other formations not previously named in the lepidopterous thorax require descriptive terms by which they may be designated in such a paper as this one.

Each typical wing-bearing segment in the Lepidoptera has a *pleural suture* (*c*) (see text figure), traversing the pleural region from the *pleural wing process* (*wp*) to the coxa. The part of the pleuron anterior to the suture and which "always extends from the top to the bottom of the pleural plate" (Crampton, 1914a), is called the *episternum* (*es*) while that posterior to it is the *epimeron* (*em*). Quoting from Young (1921), "The straightness of the pleural and coxal ridges is a mark of primitiveness." While this is a general truth in the case of the pleural suture, it is not strictly so in the two species figured for illustration of these terms. The aegeriid *Melittia satyriniformis* (Fig. 1) has the pleural suture (or "ridge") extremely curved, while *Catocala concumbens* (Fig. 2), in a family considered to be more highly developed in general than the Aegeriidæ, has a pleural suture less curved. However, *M. satyriniformis* may be considered a member of a lower family which has particularly developed so as to bend the pleural ridge out of proportion to the rest of its development.

In this order the basicoxite is enlarged by the distal extension of *the basicostal suture* (*bc*) on the coxa posteriorly to form the large *meron* (*m*), as is the case in the Neuroptera, Mecoptera, Trichoptera, some Diptera, etc. Snodgrass (1927) figures the coxa of *Conopia* (*Aegeria*) *exitiosa* Say and discusses the relationships of the basicoxite. In such

families as the Micropterygidæ (Fig. 5), Hepialidæ (Fig. 6), Megalopygidæ (Fig. 9), Pyromorphidæ (Fig. 18), and Psychidæ (Fig. 16) there is none of the anterior part of the basicoxite visible externally. In *Adela purpura* Wlk. (Fig. 8) and in most of the higher families there is in the angle of the eucoxa between the meron and the pleuron a small sclerite which may be called the *epicoxal piece* (*x*); it is undoubtedly the exposed part of the basicoxite anterior to the pleural articulation of the coxa.



DIAGRAMMATIC STRUCTURE OF THE TYPICAL LEPIDOPTEROUS MESOPLEURON AND STERNUM.

a, anepisternal suture; *aes*, anepisternum; *bc*, basicostal suture; *bs*, basisternite; *c*, pleural suture; *ec*, eucoxa; *em*, epimeron; *es*, episternum; *fs*, furcisternite; *g*, marginopleural suture; *h*, midventral suture; *m*, meron; *pem*, preepimeron; *pes*, preepisternum; *sa*, subalare; *sl*, sternal lobe; *ss*, spinisternite; *w*, preepisternal suture; *wp*, pleural wing process; *x*, epicoxal piece; *y*, precoxal suture; *z*, anepisternal sutural connective.

A typical subdivision of the mesothoracic episternum occurs in the Lepidoptera. A longitudinal suture cuts the episternum of this segment in nearly equal parts, the upper smaller one being the *anepisternum* (*aes*), and the lower the *katepisternum*. The katepisternum is fused to such an extent with the sternal regions and then so divided by secondary sutures that other terms have been found more useful in such orders as the Neuroptera, Mecoptera, Trichoptera, Lepidoptera, etc. The lower region of the episternum together with the sternum is termed the *sternopleurite* (*spl*).

A process is found in many of the more highly developed Lepidoptera, such as the Glyphipterygidæ, Aegeriidæ, Geometridæ, Noctuidæ, Sphingidæ, Saturniidæ, etc., which may be called the *sternal lobe* (*sl*) (see text figure), and is an anterior projection of the lower region of the episternum which overhangs the sternum. It is sometimes very prominent and covers a considerable pocket which extends entirely across the sternal region.

The *anepisternal suture* (*aes*) is a very useful landmark. In very few cases, such as *Thyris maculata*, has it been found lacking. It is usually present as a membranous open cleft (*Episternalspalt*, Weber, 1928), extending from the anterior margin of the episternum about three-quarters of the distance to the pleural suture. Sometimes it is closed, the opposite margins of the cleft being drawn together. Sometimes it extends entirely to the pleural suture, but usually the posterior part is only slightly visible as an internal thickening of the exoskeleton. Usually when a connection with the pleural suture is visible, there is a tendency, especially in the higher families, for the *anepisternal sutural connective* (*z*) to migrate down that suture. In *M. satyriniformis* the anepisternal sutural connective has migrated to the lower end of the pleural suture.

In *Corydalis cornuta* L. (Neuroptera), (Fig. 3) there is a secondary suture extending from the posterior end of the anepisternal suture directly to the midventral suture cutting the sternum into *basisternite* (*bs*) anteriorly and *furcisternite* (*fs*) posteriorly. This suture may be termed the *precoxal suture* (*y*). In many groups of Lepidoptera the anepisternal sutural connective is missing but from the posterior end of the anepisternal suture the precoxal suture curves ventrad, sometimes approaching the region of the sternal lobe, sometimes, on the other hand, migrating toward the coxa or even connecting with the *marginopleural suture* (*g*). In the Geometridæ (Figs. 30 and 31) a curious thing apparently happens to this suture. The pleural suture is very deeply inrolled and the episternum is drawn in so far that the precoxal suture is hidden for a distance therein, the lower part arising from the pleural suture just above the origin of the marginopleural suture.

From a point near the anterior end of the anepisternal suture the *preepisternal suture* (*w*) extends ventrally to the sternal lobe to join the precoxal suture. The region anterior to the preepisternal suture is the *preepisternum* (*pes*) (Crampton, 1914b). In Figure 1 it is seen that the preepisternal suture is slightly demarked, while in the Noctuidæ (Fig. 2) it is very prominent and extends entirely to the anepisternal suture.

In some Zygaenoidea and Pyralidoidea there is a tendency for the anterior part of the mesothoracic epimeron included in the bend of the pleural suture to be marked off from the main part of the epimeron by a more or less distinct furrow or suture. In the Geometridæ there is a greater demarkation of this small anterior region, although the separation is usually very incomplete. In the Noctuidæ and related families, and in the Sphingidæ, a heavy suture, sometimes nearly as prominent

as the pleural suture, marks off this anterior part, which may be appropriately termed the *preepimeron* (*pem*) (Fig. 2). Sometimes another demarkation of the epimeron occurs in which a line extends dorsad from its lower margin. It usually becomes a furrow parallel to the subalar membrane posteriorly (Fig. 1).

In the metathorax of Lepidoptera there is the development of a truly lepidopterous structure at the base of the wings on the dorsal margin of the episternum. In *Micropteryx aruncella* Scop. (Fig. 5) there is a slender vertical projection parallel to the wing process and directly anterior to it which is probably homologous with the *posterior basalare* of Crampton's typical thoracic segment (1914a). Snodgrass (1927) figures a similar structure in *Psocus*. This basalar plate is connected with the episternum at the base of the wing process and apparently is developed in some Lepidoptera to assist that process in supporting the hind-wings. Anterior to the base of the posterior basalare in *Micropteryx* is a small posteriorly curved lobe. This becomes in *Hepialus* (Fig. 6) a much enlarged flap-like projection from the episternum anterior to the wing-base. In slightly more advanced groups such as the Incurvariidæ (Adelidæ) (Fig. 8), the *anterior basalare* (or *basalar pad, ba,* as it may be called in the Lepidoptera) is fully developed as a cushion-like swelling, not thick-walled as are the surrounding regions but delicate and often covered with short setæ. In Figure 1, showing *Melittia satyriniformis*, the basalar pad is not so clearly demarked as is usual. This appearance may be that which would be found in a stage between *Micropteryx* (Fig. 5) and *Adela* (Fig. 8) in its development.

A line which sometimes appears in the metathoracic episternum may be called the *metepisternal suture*. It usually arises from a slight dorsad angulation of the marginopleural suture.

The epicoxal piece is usually visible in the metathorax, if it is so in the mesothorax.

NOTES ON THE MORPHOLOGY OF THE PLEURAL AND STERNAL REGIONS OF THE MESOTHORAX AND METATHORAX IN THE LEPIDOPTERA AND ALLIED GROUPS.

The following notes are arranged, for the most part, by families in the order that W. T. M. Forbes follows in "The Lepidoptera of New York and Neighboring States" (1923), and in "A List of the Insects of New York" (1926), since these are the most recent works of this type in general use. The figures in many cases show both the pleural and sternal regions of the mesothorax; other figures show only the lateral view as seen without turning the insect.

Order **Neuroptera.**

The lateral view of the thorax of *Corydalis cornuta* L. has been figured by Crampton (1909 and 1914a). Weber (1924 and 1928) has studied the thorax of *Sialis*, giving many extremely useful figures of the exoskeleton and the musculature. As *C. cornuta* is a conveniently large species to show the details of the neuropterous type, the mesothoracic view is figured again (Fig. 3) in this paper. Important details to be noted are:

1. A small button-like sclerite, the forerunner of the *tegula* (*t*) which is applied about the base of the wing anteriorly in Lepidoptera.
2. The straightness of the pleural suture, its lower end forming the lateral condyle upon which the coxa hinges; and the distal extension of the basicostal suture which divides the first joint of the leg into meron and eucoxa as is also the case in the Trichoptera and Lepidoptera.
3. The prominence of the anepisternal suture or cleft. This character is also strongly developed in the Trichoptera and Lepidoptera.
4. The *precoxal suture* (*y*) divides the sternal region into a *basisternite* (*bs*) anteriorly and a *furcisternite* (*fs*) which lies between the coxæ.
5. The sclerites extending ventrad from the region of the trochantin across a large membranous area to the coxa anteriorly continue in such Trichoptera as *Neuronia* (Fig. 4), but seem to be lost, or hidden by infolding or thickening of membranous areas, in the Lepidoptera. In *Phassus* (Fig. 6) and *Micropteryx* (Fig. 5) of the Jugate Lepidoptera the prominent membranous areas separating the coxæ from the pleural and sternal sclerites are very much like those found in *Corydalis* in the Neuroptera and to less extent, and mainly in the mesothorax, in *Neuronia* in the Trichoptera.

Order **Trichoptera.**

Neuronia (Fig. 4) is used to represent the Trichoptera. It is not taken as a primitive species but because it shows characteristics indicating the relationship existing between Trichoptera and Lepidoptera. These may be thought of as characteristics retained in common by both Lepidoptera and Trichoptera from an ancestor perhaps more neuropterous than otherwise. The conception given by Tillyard (1919) is much the idea intended.

1. In *Neuronia* the prothorax is in many ways like that of a lepidopteron. The patagial forerunner is present as a broad plate bearing a slightly elevated wart-like area anteriorly, having in this regard much similarity to *Phassus* and *Micropteryx*. The lateropleurite of the prothorax passes under the anterior part of the patagial sclerite as in such moths as *Prionoxystus* (Fig. 21) and *Thyridopteryx* (Fig. 16).

2. In the mesothorax the anepisternal suture is situated considerably ventrad. The precoxal suture is very distinct and passes from the inner end of the anepisternal suture to a point anterior to the coxa. The anepisternal sutural connective is also very distinct and complete.

3. In the metathorax is a large sclerite at the base of the pleural wing-process, from which the episternal part of that growth arises. It is undoubtedly from a similar division of the metathorax that the basalar pad (anterior basalare) is formed. Below this sclerite other divisions appear which show distinct relation to those in the episternum of *Micropteryx* and *Eriocrania* of the jugate Lepidoptera. In the frenate Lepidoptera it is very difficult to trace the same relationships. From these observations it will be seen that here is but another evidence of the closeness of the Jugatæ to their trichopterous cousins, and that the frenate Lepidoptera are considerably removed from them on other lines of development.

Hermann Weber (1924) figures the lateral view of the thorax of *Psychomia*. The latter is very similar to that of *Neuronia* shown in this paper. Crampton (1920) figures a lateral view of the thorax of *Philopotamus distinctus* Wlk.

Order **Lepidoptera.**

Suborder **Jugatæ.**

Micropteryx aruncella Scop. (*sepella* Fab.) (Micropterygidæ) (Fig. 5) shows certain characters in the lateral view of the thorax which would indicate a secondary division of the mesothoracic epimeron into upper and lower regions in the jugate Lepidoptera. This division is also indicated in *Eriocrania auricyanea* Wlsm. (not figured here but shown in the lateral view in the paper by Crampton, 1920) and less so in *Phassus huebneri* Geyer (Hepialidæ) (Fig. 6).

The tegula at the base of the fore-wing is slightly developed in both *Micropteryx* and the trichopteron *Neuronia*. It is perhaps a little more highly developed in the hepialid *Phassus*, where it is a membranous pad which surrounds the base of the wing as does the thicker-walled tegula in the higher families of Lepidoptera.

Suborder **Frenatæ.**

Incurvarioidea:

Two members of the family Incurvariidæ have been studied, *Tegeticula yuccasella* Riley (Fig. 7) and *Adela purpura* Wlk. (Fig. 8). They present a very distinct family character in the mesopleural region,

namely, a triangular sclerite next the pleural suture and on the dorsal side of the marginopleural suture.

It is in the Incurvariidæ that for the first time a greater share of the characteristics are displayed which are found in the secondary divisions of the thorax of the higher Lepidoptera. The figure of *Tegeticula* shows the typical lepidopterous sternum. The sternopleurite of *Corydalis* (Fig. 3) is a wide unbroken plate. In *Tegeticula* (Fig. 7) a membranous gap in it has appeared extending to the precoxal suture. The sternal division is bounded by a sharply defined margin while the pleural is more or less indistinct and becoming lobe-like, tendencies which become more and more pronounced in higher families. The furcisternum is moderately wide in *Tegeticula* but becomes narrow to entirely disappearing in other families.

Zygaenoidea:

Three families are included in this group, two of which are represented by *Megalopyge crispata* Pack. (Megalopygidæ) (Fig. 9) and *Cnidocampa flavescens* Wlk. (Eucleidæ) (Fig. 10), figured in this paper. *Harrisina americana* Guerin (Pyromorphidæ) has also been examined.

These species show a decided tendency toward formation of a preepimeron although in no case has this plate been found to be defined by more than a shallow furrow or an abbreviated suture.

In the Megalopygidæ and Pyromorphidæ the precoxal suture is bent toward the pleural suture to such an extent that it is in part enveloped in that groove. In the eucleid *Cnidocampa*, however, this is not the case. There is in the latter species a triangular sclerite very similar to that which characterizes the Incurvariidæ.

Tineoidea:

Three families in this group have been studied, the species that have been taken to represent them being *Tineola biselliella* Hummel (Tineidæ) (Fig. 13), *Thyridopteryx ephemeraeformis* Haw. (Psychidæ) (Fig. 16), and *Lithocolletis* sp. (Gracilariidæ) (Fig. 15).

In this group the *spinisternite* (*ss*) is found to be well developed. H. Weber (1924) gives a full page of drawings of the sterna of *Sialis*, *Psychomyia*, *Hepialis*, *Zygaena*, and *Papilio;* and shows the manner in which the prothoracic sternites are progressively developed as the various types are considered. He found that the spinisternite was not developed in *Hepialis* but appeared in the frenate families which he studied. Amongst those species studied in the course of the present investigation, *Tineola* has the posterior fork-like part of the spinisternite* of the prothorax surrounded by a less heavy-walled area which occupies a considerable space anterior to the basisternum of the mesothorax.

In both *Tineola* and *Lithocolletis* the furcisternite is rather broad, but in *Thyridopteryx* it is very narrow and hidden.

* In all cases in which the spinisternite is mentioned in this paper reference is made to the part of it (sometimes entirely separated) posterior to the spina which is more or less closely associated with the basisternite of the mesothorax in Lepidoptera. In general the prothorax is not discussed in this paper.

Thyridopteryx has the spinisternite produced on each side laterally as an arc the inner margin of which near the tip is fastened to the margin of the sternum posterior to it.

Lithocolletis has taken a course of development opposite to that of *Tineola* in that the anterior part of the pleuron between the anepisternum and the sternum has become membranous over an area extending halfway to the pleural suture.

Cycnodioidea (Elachistoidea):

One species has been studied in this superfamily, viz., *Aphelosetia* sp. (Cycnodiidæ) (Fig. 12). It will be seen by comparing the figures that this species is much like *Lithocolletis* (Fig. 15) in the demarkation of the mesopleuron and mesosternum. The antero-lateral areas are more thickly walled and the precoxal suture does not meet the pleural suture.

Gelechioidea:

Following the tendencies previously noted for the Zygaenoidea, the members of the gelechioid families, and especially the Gelechiidæ, show a still more complete separation of a preepimeron from the epimeron of the mesothorax. This is in direct contrast to the lack of any such division in the Tineoidea and Cycnodioidea.

Depressaria atrodorsella Clem. (Oecophoridæ) (not figured) shows the precoxal suture meeting the anepisternal suture at its posterior end; *Ypsolophus ligullelus* Hbn. (Gelechiidæ) (not figured) shows those sutures nearly in junction at that point; whereas in the only species figured in this group, *Phthorimaea operculella* Zell. (Gelechiidæ) (Fig. 19) the precoxal suture is but slightly developed.

Yponomeutoidea:

Species studied and figured are *Atteva punctella* Cram. (Yponomeutidæ) (Fig. 17) and *Simaethis pariana* Clerck (Glyphipterygidæ) (Fig. 14). *Melittia satyriniformis* Hbn. (Aegeriidæ) (Fig. 1), discussed in the first part of this paper, belongs to this group.

The outstanding features of the mesopleuron and the sternum of this group are: 1. The projection of the sternal lobe ventrally from the partially demarked preepisternum. 2. The preepimeron slightly or but partially defined. 3. The demarkation, at least in *Atteva* and *Simaethis*, of a narrow presternum along the anterior margin of the sternum.

Tortricoidea:

Very few species in this group have been examined. Some further study and comparison of the various types within the families will be of interest and applicable in fixing the family characteristics. *Carpocapsa pomonella* L. (Fig. 23) and *Archips* sp. (Fig. 11) are representative of two of the subdivisions of the Tortricidæ, while *Prionoxystus robiniæ* Peck (Fig. 21) has been taken to represent the Cossidæ.

All three species show many characters in common, both in the mesopleura and in the metapleura. Only in *Carpocapsa* is the meso-

thoracic preepimeron at all defined and even here it is still partially connected with the rest of the epimeron. In *Archips* the region of the sternal lobe is entirely membranized, in *Prionoxystus* that region is rather flat and illy defined, while in *Carpocapsa* it appears as a rather low but distinctly-formed lobe. There is also a marked difference in the three species as to the position of the precoxal suture as may be seen by reference to the figures of the respective species. It will be noticed that *Archips* has a very decided similarity to the tineoid *Lithocolletis* (Fig. 15) in respect to the mesothoracic pleuron and sternum.

Pyralidoidea:

Aside from *Thyris maculata* Harr. (Thyrididæ) (Fig. 20), the studies in this group have been entirely amongst the various subfamilies of Pyralididæ, namely *Galleria mellonella* L. (Galleriinæ) (Fig. 24), *Desmia funeralis* Hbn. (Pyraustinæ) (Fig. 22), *Crambus* sp. (Crambinæ) (Fig. 25), and *Ephestia kuehniella* Zell. (Phycitinæ) (Fig. 26).

In the mesothorax of *Thyris* is seen a remarkable development of that suture which defines the preepimeron, and still more noticeable, the entire loss of the anepisternal suture and the formation of two very long narrow branches of the prothoracic spinisternite which extend separately nearly or quite to the spina. The sternal lobe seems to have become flattened out and resembles, at least superficially, a condition in the Papilionoidea where the preepisternum does not tend to overhang a part of the sternum.

The Pyralididæ examined show a highly developed sternal lobe, bending ventrad to cover parts of the mesosternum. There is a characteristic forking of the marginopleural suture of the mesopleuron, both forks nearly or quite reaching the pleural suture. The latter character is also true of *Thyris*. The pleural suture is slightly bent in all species.

Saturnoidea:

Automeris io Fabr. (Saturniidæ) (Fig. 28) presents a rather simple pleural map. The sternal lobe has a sharp deep pocket beneath it. The suture marking off the preepisternum is very distinct and extends to the anepisternal suture near its anterior end, a character also found in *Anisota senatoria* S. & A. (Citheroniidæ) (Fig. 38).

Bombycoidea:

Bombyx mori L. (Bombycidæ) (Fig. 27) is in general similar to *Automeris*.

Malacosoma americana Fabr. (Lasiocampidæ) (Fig. 29) does not have the preepisternum demarked and the sternal lobe is broader.

Apatelodes torrefacta S. & A. (Eupterotidæ) (Fig. 35) has the anepisternum of the mesothorax very much swollen. The spinisternite is narrow, the ends of the obtuse fork joined to the sternum posterior to it. The preepisternal suture meets the anepisternal cleft some little distance from the opening of the latter. As in the other species of Bombycoidea and those also of Saturnoidea that were studied there is no preepimeron.

Drepanoidea:

Oreta irrorata Pack. (Drepanidæ) (Fig. 32) has no sternal lobe; the precoxal and marginopleural sutures are prominent, and likewise the ventral half of the preepisternal suture. The preepimeron is moderately defined. The part of the pleural suture between the wing-process and the preepimeron is rolled over the episternum so that two layers of the body-wall are covered by the membranous area below the wing.

Geometroidea:

Brephos infans Moeschler (Brephinæ) (Fig. 31) and three species of Geometrinæ (*Erannis tiliria* Harr., Fig. 30; *Ectropis crepuscularia* D. & S.; and *Abbottana clemataria* S. & A.) have the upper part of the pleural suture hidden as in the Drepanidæ. The sternal lobe is absent or not prominent, the preepimeron is not strongly demarked, and the precoxal suture is not present in the Geometroidea examined. The preepisternal suture is very short, extending only about a third of the distance from the coxa toward the anepisternum. The prothoracic spinisternite is acutely forked with the branches narrow, whereas in the Saturnoidea it is obtusely forked.

In the Geometrinæ the spinisternite is joined to the basisternite which is only moderately arched cephalad. In *Brephos infans* (Brephinæ), however, it is free, the anterior margin of the basisternite very acute and extending some distance cephalad between its branches. It is characteristic of this forked type of spinisternite that the branches approach or are joined posteriorly to the basisternite at a point very close to the furrow beneath the sternal lobe.

Sphingoidea:

Sphinx gordius Stoll (Fig. 33), *Amphion nessus* Cram. (Fig. 48), and *Phlegethontius sexta* Joh. have moderately produced sternal lobes and definite preepisterna in the mesothorax, much as in *Carpocapsa* (Tortricidæ). The preepimeron is completely and markedly separated from the rest of the epimeron, the upper end of it produced dorsad and lying in a cavity over the pleural suture. This cavity extends into the anepisternum dorsally. In *Amphion* the branches of the spinisternite are lanceolate with a very narrow juncture at the midventral line.

Noctuoidea:

The members of this group must be very closely related to the Sphingoidea, judging by the lateral aspect of the thorax. The greatest differences lie in the shape of the spinisternite which, however, seems to vary in form between allied genera or groups of genera. In all the families the preepimeron is particularly well developed and the preepisternal suture reaches nearly or quite to the anepisternal suture.

In the Notodontidæ, *Melalopha inclusa* Hbn. (Fig. 39) and *Datana ministra* Drury (Fig. 37) have been examined. *Melalopha* has the preepisternum considerably enlarged and lying over a part of the sternum; the preepisternal suture is rather short and has migrated toward the pleural suture. The narrow branches of the prothoracic

spinisternite extend very far cephalad before uniting. *Datana* is very similar to the typical noctuid in the fact that the preepisternal suture extends to the anepisternal cleft. The spinisternite is narrow and acute but not as much so as in the previous species; it is joined to the basisternite of the mesosternum.

The Liparidæ which were studied (*Hemerocampa leucostigma* S. & A. (Fig. 40) and *Stilpnotia salicis* L.) have the membranous subalar region extending well down toward the meron of the coxa. In *Hemerocampa* the preepisternal suture extends in a nearly straight line to a point close to the anepisternal suture. The spinisternite is narrow and somewhat acutely angled.

Members of various subfamilies of the Noctuidæ have been examined. In general they are very similar and much like *Datana* of the Notodontidæ. The precoxal suture appears as a more or less well-defined line in most of the species. An undetermined species of Hypeninæ has the branches of the spinisternite attached broadly to the basisternite; the preepimeron is nearly round. *Alabama argillacea* Hbn. (Erebinæ) has an extremely acutely branched spinisternite and the sternal lobe overhangs the sternum as it does in *Melalopha* (Notodontidæ). The anepisternum of *Autographa falcigera* Kirby (Plusiinæ) (Fig. 43) extends farther ventrad than usual. In *A. basigera* Wlk. the precoxal suture bends cephalad not more than halfway to the preepisternal suture instead of joining with it as in *A. falcigera;* both species have the spinisternite joined to the basisternite. *Zale undularis* Drury and *Catocala concumbens* Wlk. (Fig. 2), both Catocalinæ, resemble each other closely; the spinisternite is typically joined; the species are alike in having the precoxal suture visible for only a short distance. *Lithacodia carneola* Gn. (Erastriinæ) is very similar to the previous group. *Pyrophila pyramidoides* Gn. and *Septis arctica* Lef. (Fig. 34) of the Acronyctinæ are very much alike; moreover *Eucirrhoedia pampina* Gn. (Cuculliinæ) has almost exactly the same thoracic pleural map as has *Pyrophila.* Of the Agrotinæ, *Lygranthoecia marginata* Haw. (Fig. 36), *Feltia subgothica* Haw., *Lycophotia margaritosa* Haw., *Matuta prasina* Fabr., and *Heliothis obsoleta* Fabr. have been examined. In general the spinisternite is obtusely forked, thus differing from the acute forking in most of the Noctuidæ. In *Lycophotia* the spinisternite differs from the other Agrotinæ that have been studied in that it bears a midventral suture like that which is present in the sternum proper.

The Arctiidæ possess the same general characteristics in the regions under discussion as do the Agrotinæ, the only differences worth mentioning here belonging to the sternum. In *Utetheisa bella* L. the obtusely forked spinisternite is broadly attached to the basisternite, possibly somewhat farther from the sternal lobe than is the usual case in the Noctuidæ. *Isia isabella* S. & A. is very similar but with a broader preepisternum and with the arms of the spinisternite more slender and straight, and not attached to the basisternite. The spinisternite of *Estigmene acraea* Drury (Fig. 41 and 41A) is very different from that of all the other Noctuoidea examined in that it is joined to the basisternite less than half the distance from the midventral line to the sternal lobe, and only encloses a very small heart-shaped membranous area.

Nola ovilla Grote (Nolidæ) has characters which are similar to those of the following species, namely, lack or modification of the preepimeron, shortness of the preepisternal suture, etc. The spinisternite, however, is very narrow and with very short acutely angled arms, not diverging much from the midline; it is not like that of any of the other Noctuoidea.

Scepsis fulvicollis Hbn. (Euchromiidæ) (Fig. 42) has the spinisternite very broadly forked and as a consequence a rather narrow area between it and the anterior margin of the basisternite.

Hesperioidea:

In *Epargyreus tityrus* Fabr. (Pyrginæ), (Fig. 44) the anepisternum although clearly differentiated is smaller than in the specialized families just discussed. There is no preepimeron; the spinisternite is not fork-like although it retains its two posterior arms which do not extend far from the midventral line, the remaining space being enroached upon by the preepisternum; the latter region is diminishing dorsally. *Pyrgus tessellata* Scudd. (Pyrginæ) differs in having the anepisternum much less heavily walled than the regions below it, and a narrower spinisternite as in *Polites*.

Polites peckius Kirby (Hesperiinæ) shows a very significant variation from the pleural map of *Epargyreus* (Fig. 44). The anepisternum is still more reduced, and most of it is covered by the tegula, that part being membranous. The spinisternite has longer narrow pointed arms which lie in angles between the basisternite and the preepisterna.

The spinisternite of *Goniurus proteus* L. (Pyrginæ) is forked more as in *Polites* (Hesperiinæ), so the reduced spinisternite of *Epargyreus* is not typical of the Pyrginæ, although it is an interesting type rather similar to that of *Danaus* (Nymphalidæ) and of *Papilio* (Papilionidæ). This is another example of the variability of form of the spinisternite in rather closely allied groups of genera.

Papilionoidea:

Heodes hypophlaeas Edw. (Lycaenidæ), (Fig. 45) shows a very great resemblance to the other butterflies in the characters under discussion, while the Hesperiidæ which were examined show very little change in characters from those of the various generalized Lepidoptera studied. There is here then a considerable gap in the phylogeny of the Lepidoptera. *Heodes* is remarkable in that the anepisternum has very nearly disappeared, the preepimeron is preserved (in this matter unlike the Hesperiidæ), the precoxal suture connects with the anterior margin of the basisternite, and the preepisternum has become enlarged anteriorly between the spinisternite and the episternum. The spinisternite is long, narrow, and with a short acute fork near the midline. *Incisalia augustus* Kirby is nearly identical with *Heodes* in these characters; the spinisternite, however, has a much broader and less acutely angled fork.

In *Danaus archippus* (Auct.), (Nymphalidæ), (Fig. 50) any vestiges of the anepisternum which remain must be separated from the episternum proper and located close to the wing base. The precoxal suture resembles that of *Heodes* in emerging from the pleural suture

nearly at right angles to it a short distance dorsad of the coxa. The preepisternum is narrow and extends entirely to the wing process; its ventral end is enlarged near the spinisternite. The latter sclerite is shield-shaped with two short arms projecting caudad; it lies for two-thirds its length in a pocket formed by the enlarged ends of the preepisterna.

An examination of other nymphalid species, such as *Cissia eurytus* Fabr., *Cercyonis alope* Fabr. (Fig. 49), *Argynnis* sp., *Phyciodes tharos* Drury, *Aglais antiopa* L., and *Vanessa cardui* L., shows very little difference amongst the various subfamilies. The precoxal suture is often only partially visible and may arise at different angles. The spinisternite is always much longer and more slender than in *Danaus*, although in general the fork lies in a pocket in the same manner as in that species. In the satyrids *Cercyonis* and *Cissia* there is no preepisternal suture.

The Papilionidæ and Pieridæ show another development from the lycaenid type. *Papilio glaucus turnus* L. (Fig. 46) has a single broad sternopleural plate extending from the midventral line to the pleural suture and the vestigial anepisternum. The precoxal suture has disappeared and the sternopleural plate has broadened anteriorly. The pierids *Pieris rapæ* L., *Eurymus philodice* Godt. (Fig. 47), and *Eurema* sp. likewise show these characters. *Papilio* has a shield-shaped spinisternite situated much as is that sclerite in *Danaus* (also see Fig. 87 of *Papilio*, Crampton, 1926). In the pierids examined, however, the spinisternite is long, slender, and more sharply forked; moreover, a triangular presternum directly behind the spinisternite appears in the Pieridæ apparently as an enlargement of a very small plate in that position in Papilio. The pierid meron extends half again as far dorsad as the anterior portion of the coxa.

NOTES ON THE THORACIC MUSCULATURE.

A few dissections of the thorax have been made for the purpose of homologizing some of the characters more accurately.

Musculature of the anepisternum.

The basalar muscles of the coxa and preepisternum are attached to a small thickened arm, the ba alare, at the dorsal margin of he anepisternum. In the Lepidoptera, then, the basalare comprises only a small muscle attachment slightly if at all separated from the anepisternum. The latter sclerite, aside from the muscles attached to the thickened arm at its dorsal margin, bears none of the basalar muscles from the coxa and sternum. Therefore there can be little doubt that it is not an enlarged basalare but is best termed the anepisternum.

In order to determine the fate of the anepisternum in the Papilionoidea, dissections of various species were made, and compared with the neuropteron *Corydalis* and moths of the specialized family Noctuidæ. In *Corydalis* the flexor muscle of the third axillary plate of the wing base is attached in two parts, one to the pleural apodeme,

the other larger one to the anepisternum. Weber (1928) shows this muscle in *Sialis*, where the same condition prevails. The noctuid moths (species undetermined) that were examined have this muscle attached as in these Neuroptera. For comparison may be mentioned a figure of the grasshopper *Dissosteira* (Snodgrass, 1927, Fig. 30) where this muscle is apparently broadly joined only to the posterior side of the pleural apodeme.

A different condition appears when the butterflies are studied. The hesperiid *Epargyreus tityrus* has as distinct an anepisternum as *Corydalis* and the noctuid moths. The attachment of the muscle of the third axillary, however, is not on the anepisternum in *Epargyreus* but upon the middle of the sternopleurite below the anepisternal suture. The smaller muscle which usually lies under this muscle is present and attached as usual to the posterior face of the pleural apodeme. In *Danaus archippus* and *Eurymus philodice* the muscular attachment is on the sternopleurite; in the former it is next the preepisternal suture while in *Eurymus* attachment occurs very close to the pleural apodeme.

In view of the fact that the muscle which is usually attached to the anepisternum in moths and Neuroptera is attached to the plate ventral to it in *Epargyreus* where the anepisternum has not disappeared, it is reasonable to conclude that in the Papilionoidea (Figs. 45 to 50 except 48) the anepisternum has not necessarily fused with the sternopleurite. The length of the preepisternum leads to the same conclusion.

Musculature of the basalar pad.

In *Epargyreus* the metathoracic basalar pad bears a muscle attachment on its interior to which is fixed a large wing muscle from the eucoxa. This fact fixes the nature of this sclerite as a basalare.

Musculature of the precpimeron.

In the Noctuidæ where the preepimeron is well developed is a short flat muscle which lies within the preepimeron and from the ventral end of which extends a long tendon to the furca. This muscle with its attachment is shown in Berlese (1909, Fig. 463). In Weber (1928) it is shown as a narrow muscle (Zwischenmuskel) in *Sialis* arising from the posterior face of the pleural apodeme and attached to the furca anteriorly.

GENERALIZATIONS.

These conclusions concerning the relationship of lepidopterous families, it must be remembered, are based entirely upon the characters described in the preceding notes. It can not be expected that any one character will parallel every other one in a series of different species arranged according to their supposed phylogeny. It is therefore remarkable to what an extent the various characters follow along the same phylogenetic path, to present nearly the same arrangement of families when different characters are used as the basis of arrangement.

When we attempt to derive from the comparison of various related species the antecedents of each of those species, we are continually faced by the varying results of the divergence of species from their extinct common stocks and so must exercise care in assigning definite relationships in many cases.

Those relationships which may be stated from the preceding notes may be summarized as follows:

1. The jugate families show marked relationship to the Trichoptera, and distinct separation from the frenate types.

2. The Eriocraniidæ and Micropterygidæ appear to arise close together while the Hepialidæ show some entirely different characters.

3. The "micro" families as a whole give evidence of the development of characters which are incorporated in various combinations into the structure of the more specialized "higher families." These characters are much more stable and uniform in the latter.

4. There seem to be two general lines of development of the specialized Lepidoptera, viz., that which culminates in the Noctuoidea and that which has produced the Papilionoidea. The morphology of the thorax would indicate that the noctuid line arises in the manner shown in the phylogenetic scheme of W. T. M. Forbes (1923). The evidence here (especially that of the preepisternal suture and the preepimeron) would indicate, however, that the Sphingidæ should be very close to the Noctuoidea, with the Geometroidea and Drepanoidea close together on one lower branch, and the Saturnioidea and Bombycoidea together on another branch arising between the Geometroidea and the Noctuoidea.

5. The thoracic characters of the noctuoid families indicate rather clearly that the Arctiidæ should be placed very close to the Noctuidæ and probably are higher on the same general line. The Noctuidæ are very close to and probably derived from the Notodontidæ. The Nolidæ and Euchromiidæ are close together; the former has been derived from the Arctiidæ, but the characters under examination in this study would indicate that it is not related and is even more primitive than some of the previously mentioned families. The lack of a preepimeron in the Nolidæ and Euchromiidæ as in the Liparidæ may indicate that these three families are close together but this evidence is too slight to form the basis of a definite assumption. The Liparidæ probably arise close to the Notodontidæ.

6. The derivation of the papilionoid line of descent presents considerable difficulty. A. D. Imms (1924, p. 438) says:

"The Papilionina are a tolerably natural group, but there is no general consensus of opinion as to their phylogeny. Both Hampson and Meyrick regard them as being derived from the Pyraline family Thyrididæ while other authorities derive them from the Castniidæ."

By referring to the figure of *Thyris* (Fig. 20) it will be observed that this species has no anepisternal suture but that there is no evidence that the anepisternum has disappeared as in the Papilionoidea but has merely been joined to the region ventral to it through disappearance of the suture. There is a similarity in the appearance of the preepisternum of *Thyris* to that of the Papilionoidea, but little can be judged from this character because of its variability.

There is one point in favor of the descent of the Papilionoidea from the cossids, supposed to be the antecedents of the castniids. *Carpocapsa* and *Archips* of the Tortricoidea, which includes the Cossidæ, have the precoxal suture arising close to the pleural suture and crossing the pleuron diagonally to the anterior margin of the basisternite as in such butterflies as *Danaus* and *Cercyonis*. It is to be expected that by the reduction of the anepisternum and the infolding of part of it in the groove of the pleural suture, the precoxal suture which arises from the anepisternal would appear some distance down the pleural suture. This infolding of a part of the episternum within the pleural groove is seen to some extent in the Geometridæ where the precoxal suture disappears for a short distance. *Lithocolletis* of the Tineoidea shows the same characteristic as mentioned above for the Tortricoidea. Both the Tortricoidea and the lower families of the noctuoid line are supposed to arise from the Tineoidea.

7. The arrangement of the papilionoid families according to thoracic characters seems to be quite clear. The Lycaenidæ probably give rise to two lines, in one of which the precoxal suture is preserved (Nymphalidæ), and in the other is lost (Papilionidæ and Pieridæ).

W. T. M. Forbes (1923) says that in the butterflies, "the line of descent through Hesperiidæ and Papilionidæ to the Pieridæ is clear, and the Nymphalidæ are certainly a direct offshoot of the Pieridæ; but the attachment of the Lycaenidæ

is less certain." This quotation is given to illustrate the diversity of opinion concerning gross relationships which still exists, and probably will exist for many years to come.

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ABBREVIATIONS.

The subscripts 2, 3, indicate that the structures in question belong to the mesothorax and metathorax, respectively.

a.....Anepisternal suture.
aes.....Anepisternum.
ba.....Basalar pad.
bc.....Basicostal suture.
bs.....Basisternite.
c.....Pleural suture.
ec.....Eucoxa.
em.....Epimeron.
es.....Episternum.
fs.....Furcisternite.
g.....Marginopleural suture.
h.....Midventral suture.
m.....Meron.
p.....Patagium.
pba.....Posterior basalare.
pem....Preepimeron.
pes.....Preepisternum.
s.....Sternum.
sa.....Subalare.
sl.....Sternal lobe.
spl.....Sternopleurite.
ss.....Spinisternite.
t.....Tegula.
tga.....Tegular arm.
v.....Metepisternal suture.
w.....Preepisternal suture.
wp.....Pleural wing process.
x.....Epicoxal suture.
y.....Precoxal suture.
z.....Anepisternal sutural connective.

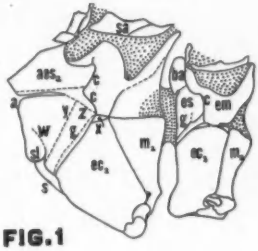


FIG. 1

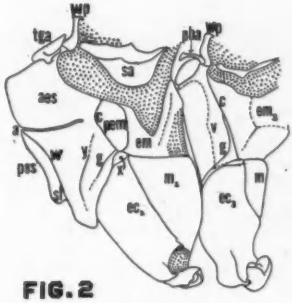


FIG. 2

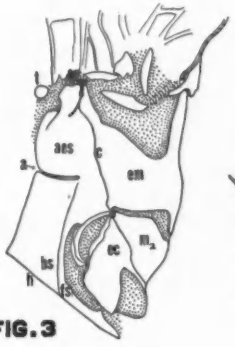


FIG. 3

FIG. 5

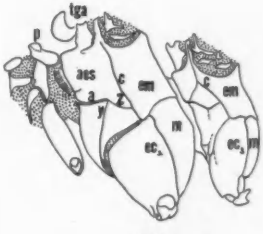


FIG. 4

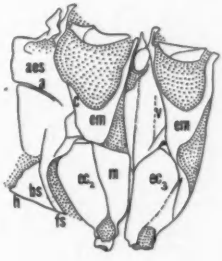


FIG. 7

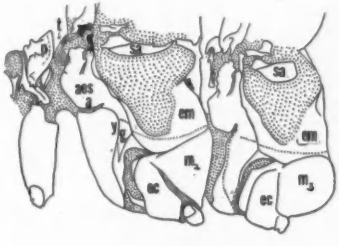


FIG. 6

Fig. 1. *Melittia satyriniformis*, mesopleuron and metapleuron.
Fig. 2. *Catocala concumbens*, mesopleuron and metapleuron.
Fig. 3. *Corydalis cornuta*, mesopleuron and sternum.
Fig. 4. *Neuronia* sp., propleuron, mesopleuron and metapleuron.
Fig. 5. *Micropteryx aruncella*, propleuron, mesopleuron and metapleuron.
Fig. 6. *Phassus huebneri*, propleuron, mesopleuron and metapleuron.
Fig. 7. *Tegeticula yuccasella*, mesopleuron, mesosternum, and metapleuron.

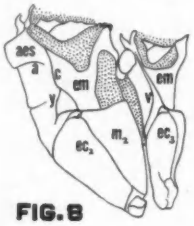


FIG. 8

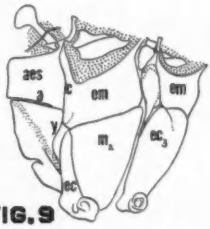


FIG. 9

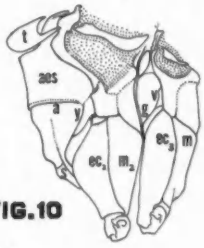


FIG. 10

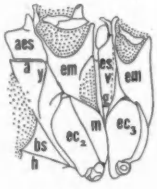


FIG. 11

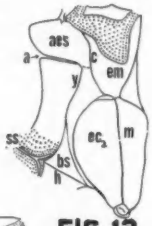


FIG. 12

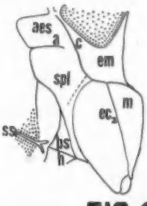


FIG. 13

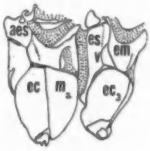


FIG. 14

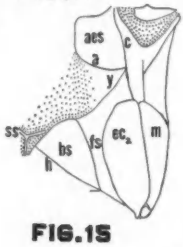


FIG. 15

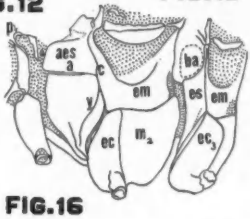


FIG. 16

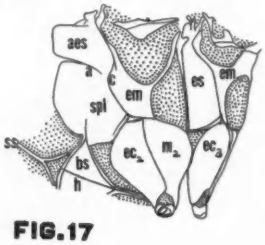


FIG. 17

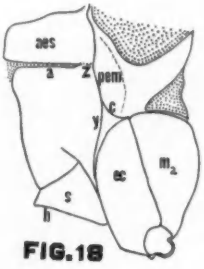


FIG. 18

Fig. 8. *Adela purpura*, mesopleuron and metapleuron.
Fig. 9. *Megalopyge crispata*, mesopleuron and metapleuron.
Fig. 10. *Cnidocampa flavescens*, mesopleuron and metapleuron.
Fig. 11. *Archips* sp., mesopleuron and sternum, and metapleuron.
Fig. 12. *Apheloseta* sp., mesopleuron and sternum.
Fig. 13. *Tineola biselliella*, mesopleuron and sternum.
Fig. 14. *Simaethis pariana*, mesopleuron and metapleuron.
Fig. 15. *Lithocolletis* sp., mesopleuron and sternum.
Fig. 16. *Thyridopteryx ephemeraeformis*, propleuron, mesopleuron and metapleuron.
Fig. 17. *Atteva punctella*, mesopleuron and sternum, and metapleuron.
Fig. 18. *Harrisina americana*, mesopleuron and sternum.

FIG. 19.

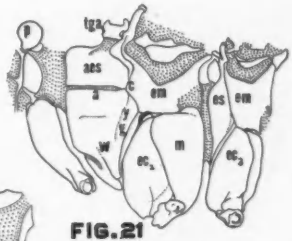


FIG. 21.

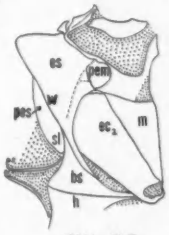
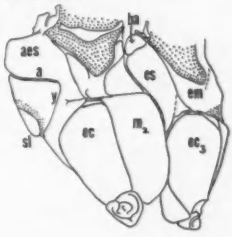


FIG. 20.



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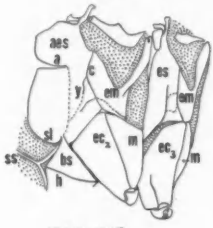

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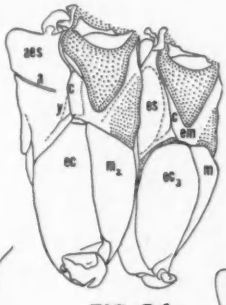


FIG. 24.

FIG. 25.

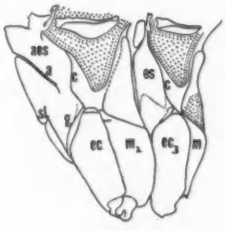


FIG. 26.

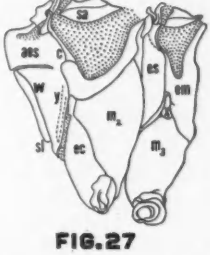


FIG. 27.

Fig. 19. *Phthorimaea operculella*, mesopleuron and sternum, and metapleuron.
Fig. 20. *Thyris maculata*, mesopleuron and sternum.
Fig. 21. *Prionoxystus robiniæ*, propleuron, mesopleuron and metapleuron.
Fig. 22. *Desmia funeralis*, mesopleuron and sternum, and metapleuron.
Fig. 23. *Carpocapsa pomonella*, mesopleuron and metapleuron.
Fig. 24. *Galleria mellonella*, mesopleuron and metapleuron.
Fig. 25. *Crambus* sp., mesopleuron and metapleuron.
Fig. 26. *Ephestia kuehniella*, mesopleuron and metapleuron.
Fig. 27. *Bombyx mori*, mesopleuron and metapleuron.

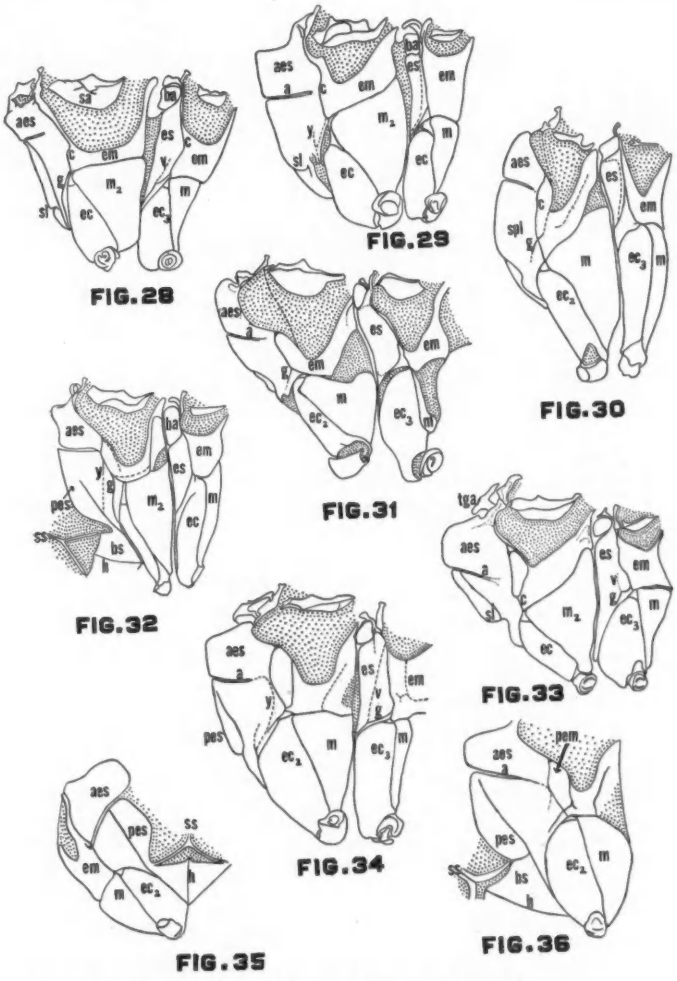


Fig. 28. *Automeris io* (male), mesopleuron and metapleuron.
Fig. 29. *Malacosoma americana*, mesopleuron and metapleuron.
Fig. 30. *Erannis tiliaria* (male), mesopleuron and metapleuron.
Fig. 31. *Brephos infans*, mesopleuron and metapleuron.
Fig. 32. *Oreta irrorata*, mesopleuron and sternum, and metapleuron.
Fig. 33. *Sphinx gordius*, mesopleuron and metapleuron.
Fig. 34. *Septis arctica*, mesopleuron and metapleuron.
Fig. 35. *Apatelodes torrefacta*, mesosternum with pleuron from below.
Fig. 36. *Lygranthoecia marginata*, mesopleuron and sternum.

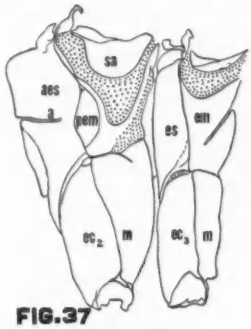


FIG. 37

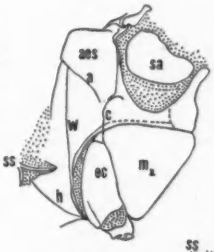


FIG. 38

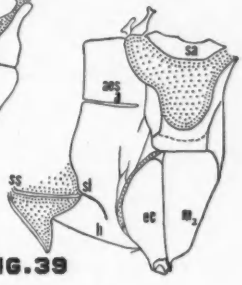


FIG. 39

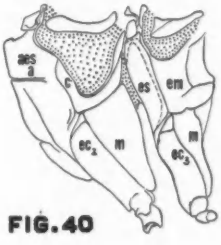


FIG. 40

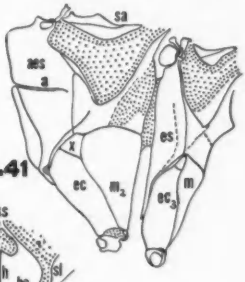


FIG. 41

A

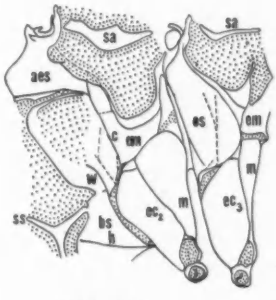


FIG. 42

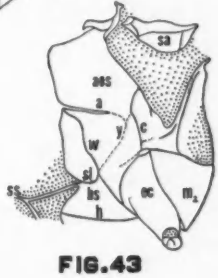


FIG. 43

Fig. 37. *Datana ministra*, mesopleuron and metapleuron.
Fig. 38. *Anisota senatoria*, mesopleuron and sternum.
Fig. 39. *Melalopha inclusa*, mesopleuron and sternum.
Fig. 40. *Hemerocampa leucostigma*, mesopleuron and metapleuron.
Fig. 41. *Estigmene acraea*, mesopleuron and metapleuron.
Fig. 41a. Same species, mesosternum.
Fig. 42. *Scepsis fulvicollis*, mesopleuron and sternum, and metapleuron.
Fig. 43. *Autographa falcigera*, mesopleuron and sternum.

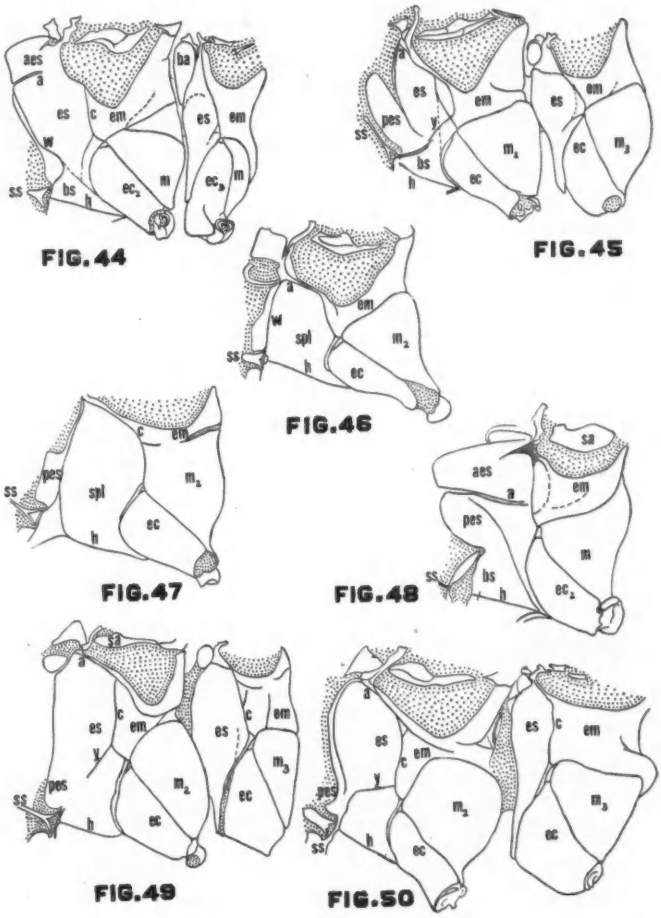


Fig. 44. *Epargyreus tityrus*, mesopleuron and sternum, and metapleuron.
Fig. 45. *Heodes hypophlaeas*, mesopleuron and sternum, and metapleuron.
Fig. 46. *Papilio turnus*, mesopleuron and sternum.
Fig. 47. *Eurymus philodice*, mesopleuron and sternum.
Fig. 48. *Amphion nessus*, mesopleuron and sternum.
Fig. 49. *Cercyonis alope*, mesopleuron and sternum and metapleuron.
Fig. 50. *Danaus archippus*, mesopleuron and sternum, and metapleuron.

THE BIONOMICS OF SOME TABANIDÆ (DIPTERA).*

ALAN STONE,
Dartmouth College, Hanover, N. H.*

Although the early stages of the Tabanidæ have been studied in considerable detail, both in this country and in other parts of the world, only a relatively few species of this large family were involved in these studies. The importance of horseflies as irritating pests of man and domestic animals, and as potential vectors of disease organisms makes a further study of their biology desirable. The following study was carried out at Ithaca, N. Y., only a few larvæ being collected elsewhere.

BIONOMICS IN GENERAL.

THE ADULTS.

Tabanidæ are generally robust flies with a stout body, large head, powerful wings and a heavy, depressed abdomen. They range in size from the smaller *Chrysops* species, no larger than a house-fly, to the large *Tabanus* species, with a wing spread of over 2½ inches.

In the majority of the species, the females are blood-sucking. They have a wide range of hosts, the larger mammals being most frequently attacked. Certain species of the genus *Tabanus* and most *Chrysops* species readily attack man. A medium-sized *Tabanus* will take from 8 to 10 minutes to complete a blood meal and will remove 0.2 cc. of blood during that time. The males exclusively, and the females to a considerable extent, feed on plant juices, excreta from certain insects, and other liquids containing nutritive material. The writer collected a female of *Tabanus orion*, one of our largest species, on Queen Anne's Lace (*Daucus carota* L.), and all of the specimens of *Buplex rasa*, five in number, on the same plant. It is doubtful if the North American *Buplex* species, or *Goniops chrysocoma*, are blood-sucking.

*This paper is a portion of a thesis presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, September, 1929.

The adults are lovers of sunlight, warmth and moisture. They possess a strong positive phototropism. They are attracted to moving objects, such as automobiles and trains, and will also collect around, and in, a standing automobile.

TABLE I.

SEASONAL DISTRIBUTION OF THE TABANIDAE AT ITHACA, N. Y.

	May	June	July	August	Sept.
Chrysops carbonarius	. . x x	x x x x	. . . .	. . . .	. . . .
Tabanus lasiophthalmus	. . x x	x x x x	x x . .	. . . .	. . . .
Chrysops cuclux	. . . x	x x . .	. . . .	. . . .	. . . .
" *celer*	. . . x	x x x x	. . . .	. . . .	. . . .
" *niger*	. . . x	x x x x	x x . .	. . . .	. . . .
" *callidus*	. . . .	. x x x	x x x x	x . . .	. . . .
" *excitans*	. . . .	. . x x	. . . .	. . . .	. . . .
" *indus*	. . . .	. . x x	x x . .	. . . .	. . . .
Tabanus carolinensis	. . . .	. . x x	x x . .	. . . .	. . . .
" *lineola*	. . . .	. . x x	x x x x	x x . .	. . . .
" *trispilus*	. . . .	. . x x	x x x x	x x x x	. . . .
" *vivax*	. . . .	. . x x	x x x x	x x x x	. . . .
" *nivosus*	. . . .	. . . x	x . . .	. . . .	. . . .
" *pumilus*	. . . .	. . . x	x . . .	. . . .	. . . .
" *trepidus*	. . . .	. . . x	x x . .	. . . .	. . . .
" *reinwardtii*	. . . .	. . . x	x x x x	x . . .	. . . .
Chrysops geminatus	. . . .	. . . x	x x x x	x x . .	. . . .
" *wiedemanni*	. . . .	. . . x	x x x x	x x . .	. . . .
Tabanus bicolor	. . . .	. . . x	x x x x	x x . .	. . . .
" *stygius*	. . . .	. . . x	x x x x	x x . .	. . . .
" *atratus*	. . . .	. . . x	x x x x	x x x .	. . . .
Chrysops vittatus	. . . .	. . . x	x x x x	x x x x	. . . .
Tabanus epistates	. . . .	. . . .	x x x .	. . . .	. . . .
" *ohioensis*	. . . .	. . . .	x x x .	. . . .	. . . .
Chrysops univittatus	. . . .	. . . .	x x x .	. . . .	. . . .
" *moechus*	. . . .	. . . .	x x x x	. . . .	. . . .
Tabanus affinis	. . . .	. . . .	x x x x	. . . .	. . . .
Chrysops montanus	. . . .	. . . .	x x x x	x . . .	. . . .
Tabanus microcephalus	. . . .	. . . .	x x x x	x x x x	. . . .
" *costalis*	. . . .	. . . .	. x x x	x x x x	x x . .
" *longus*	. . . .	. . . .	. . x .	. . . .	. . . .
Chrysops striatus	. . . .	. . . .	. . x x	. . . .	. . . .
Tabanus giganteus	. . . .	. . . .	. . . x	. . . .	. . . .
" *superjumentarius*	. . . .	. . . .	. . . .	x . . .	. . . .
Goniops chrysocoma	. . . .	. . . .	. . . .	. x x .	. . . .
Buplex rasa	. . . .	. . . .	. . . .	. x x x	. . . .
Tabanus orion	. . . .	. . . .	. . . .	. . x x	. . . .

The writer collected a number of *Tabanus* species inside of a sedan. They are attracted to water, and both sexes are often seen, either crawling down to the water's edge to drink, or dipping the tip of the abdomen into it as they fly rapidly over

the surface. The reason for the latter habit has not been explained but is of common occurrence.

Since Tabanidæ are lovers of hot weather, the flying season of the adults is relatively short. In the vicinity of Ithaca, the earlier species, such as *Chrysops carbonarius* and *Tabanus lasiophthalmus*, appear sometime in the second week of May. During the first two weeks of July, one finds horseflies in the greatest abundance, both as to species and individuals. At this time, our most abundant species, *Chrysops callidus*, *geminatus*, and *vittatus* and *Tabanus lasiophthalmus*, *costalis* and *lineola* are on the wing. By early September, most of the species have disappeared, although one may find a straggling few late into September.

Table I shows the approximate seasonal distribution of those species found at Ithaca, arranged according to the time of their first appearance. Each month is divided into four parts and the collection of a species within any fourth indicated by an x. For the rarer species, this table is of little significance.

Mating is not frequently observed. It almost always occurs in the morning, from before sunrise to about nine o'clock. When the mating pair is at rest, the male hangs inert, and when in the air, the male does the flying.

Since a large number of Tabanidæ are semi-aquatic as larvæ, it is to be expected that their eggs would be found in the vicinity of the water. This is true for most of those observed. The places of oviposition may be briefly classified as follows:

1. Foliage or other objects over shallow, quiet water; the edges of shallow pools, etc.
2. Foliage or other objects over relatively deep water, as on water plants a considerable distance from shore, and on ledges over deep water.
3. Stones projecting above the bed of a flowing stream.
4. Vegetation over either moist or quite dry soil.

The method of oviposition is quite similar in all species observed, the only differences being due to a difference in the number of layers in the completed mass and in the substratum on which the eggs are placed. The process has been described so carefully by Hine (1906) and Cameron (1926) that it is unnecessary to repeat it here.

The Egg.

The eggs are laid in masses, varying in number from 100 to 800. All of the eggs may not be laid at one time. The mass may be composed of a single layer, as in most of the *Chrysops* species, or of several layers, as in most of the *Tabanus* species. When in a single layer, they partially overlap each other. When in several layers, they stand at an angle of 45° or more to the surface. As the eggs are laid, they are covered with a gluey secretion which acts as a waterproof covering and binds the eggs together. Some species cover the egg mass with a thick, protective secretion.

The individual egg is cylindrical, narrower at the ends and either straight or slightly curved. It varies in length from 1 to 2.7 mm. and in diameter from .2 to .4 mm.

The duration of the egg stage, in bright sunlight, is from 5 to 7 days, in most species. This may be prolonged considerably if the weather is cool and cloudy, the embryo being fully developed but not hatching until favorable conditions are present or unless mechanically stimulated. All of the eggs usually hatch about the same time, the larvæ coming out in a mass and sticking together, most of them dropping to the ground or water together.

The Larva.

EXTERNAL ANATOMY.

Tabanid larvæ are characterized by possessing eleven body segments exclusive of the head and siphon, a slender cylindrical body tapering at both ends, a small retractile head with prominent downward pointing mandibles, a shiny, striated integument, and a single posterior siphon. These characters, in association with the usually visible Graber's organ within the 10th and 11th segments, will serve to distinguish all tabanid larvæ so far described, with the exception of *Goniops chrysocoma*. This anomalous species has a club-shaped body swollen posteriorly, the striæ are overshadowed by the mammillated portions of the integument, no distinct siphon is visible, and the opaqueness of the integument in older specimens completely conceals Graber's organ. In the following, more detailed description, *Goniops* is not included, but only the typical tabanid larvæ.

Head.—The head is small and may be wholly retracted or extended nearly half the total length of the head and pharyngeal capsule combined.* The mandibles are large, strong, parallel to each other, curved ventrally, often serrated along the inner margin and usually dark brown or black in color. The labrum forms a hook-like projecting septum between them. The maxillæ are well developed and wholly or largely membranous with well developed palpi. The antennæ are distinct, three jointed. Between each antenna and the dorsal median line, is a bunch of stiff, recurved bristles. These are often reddish or brownish in color. A short distance posterior to the head capsule, on each side, lies a dark ocellus.

Integument.—The non-pubescent integument is, for the most part, characterized by the presence of minute, longitudinal striæ. In certain places, they are partially or completely lacking, as in the dorsum of the thorax in the genus *Tabanus*. In other places, they are very fine and closely packed together as on the siphon. Often they are numerous on the anterior portion of an abdominal segment and fewer and wider apart posteriorly. Usually they are closer together on the lateral areas than on the dorsum or venter. The integument is ordinarily quite transparent and one can see the internal organs quite readily.

In addition to the shiny integument, there are present more or less extensive areas of fine, felt-like pubescence. This pubescence arises from the outer layer of the integument and is arranged in a fairly definite pattern, according to the species. It is usually brownish in color and probably derives much of its color from dirt particles adhering to it. In certain places, as on the anal segment of *Chrysops moechus*, the pubescent character of the covering cannot be discerned without a compound microscope. In others, especially on the anal protuberances, it is very evident.

Tabanid larvæ may be white, yellowish white, yellowish brown, olive green or distinctly green. *Tabanus trepidus*, living in sphagnum moss, is bright green. *Chrysops carbonarius* is yellowish brown to olive green. Many others, among them *Chrysops vittatus* and *C. celer*, are distinctly white or creamy-white.

Thorax.—Each of the three thoracic segments is divided into a dorsal, a ventral and two lateral areas separated from each other by the dorso-lateral and ventro-lateral lines. The prothorax is grooved along the mid-ventral line. Usually, there is an anterior ring of pubescence on each segment. Ventrally, each segment bears a more or less distinct pair of bristles. The prothorax is narrow anteriorly with the head telescoping into it. Between the prothorax and the mesothorax, in a lateral, vertical slit, there is a very small thoracic spiracle on each side.

Abdomen.—The first seven abdominal segments are quite similar in structure. The eighth is modified to bear the siphon and anus. The prolegs, on the anterior portion of each abdominal segment except

*For a very detailed description of a tabanid larva, and particularly the head, one should consult Webb and Wells (1924), pp. 14–17.

the last, consist of a dorsal transverse pair usually fused and often scarcely visible, a more or less prominent lateral pair, and two rounded ventral pairs. These prolegs are usually larger on the posterior segments. In certain species, they are very rudimentary. They often bear rows of recurved bristles at the tip. The pubescent annuli, when present, are for the most part confined to the anterior margin of abdominal segments 1-7. Posterior annuli may be present, particularly on the posterior segments. Each abdominal segment telescopes into the preceding one to some extent.

The anal segment is broad at the base and usually narrows considerably beyond the anus into a sub-conical, upward projecting portion bearing the siphon. Ventrally, the anus, a longitudinal slit, is surrounded by an anterior and a posterior anal lobe. Commonly, there is a posterior ring of pubescence around the anal segment and anterior to this either dorso-lateral projections or spots. Laterally, the anal pubescence is often joined to the posterior ring, or the whole ventral area from the anus posteriorly is pubescent.

The siphon extends from the anal segment as a rounded or elongate projection, telescoping into the anal segment. At its tip, the two tracheal trunks come in contact, the spiracle consisting of a vertical slit or a freely exsertile, sharp, compressed spine. (Figures 3 and 4.)

INTERNAL ANATOMY.

A detailed discussion of the internal anatomy is not within the scope of this work, dealing as it does, primarily, with the identification of the immature stages of Tabanidæ and with their biology. A number of the internal structures may be observed, however, in living, transparent larvæ.

The two main tracheal trunks run nearly the entire length of the body. They may be slender and quite sinuous, making a loop in the 6th and 7th abdominal segments or they may be swollen into heavy tubes serving as air chambers and narrow only near the posterior end. As far as is known, tabanid larvæ are metapneustic, the anterior spiracles not being functional. The pharynx is enclosed within the pharyngeal pouch and moves with the head. The mid-gut usually contains a colored fluid, the color depending upon the food last ingested. The Malpighian tubules ordinarily show as coiled yellowish or brownish tubes in the posterior part of the body. The very transparent, dorsal blood vessel can be seen in larger larvæ, the contractions proceeding from the back forward.

Of particular interest is Graber's organ, that peculiar pear-shaped sac, broader anteriorly with a slender tube opening near the base of the siphon dorsally. Within the sac are a number of capsules containing black, pediceled bodies. The whole structure is richly provided with nerves and muscles and in life keeps up a nearly continual, lateral oscillation. This organ has been described and its possible functions discussed so fully by more competent writers that further remarks are

superfluous. For a complete rèsumè of the literature on it, up to 1920, one should consult Marchand (1920) pp. 29–43. Cameron (1926) also writes quite fully upon it. For other features of the internal anatomy, Patton and Cragg (1913) and Stammer (1924) are particularly valuable.

GROWTH.

Almost immediately after emerging from the egg, the first ecdysis takes place. According to Webb and Wells (1924), the second instar larvæ are ready to cast the skin of the first instar before hatching, and as soon as they hatch, often before they reach the water, this is done. The writer failed to determine the number of molts in *Tabanus atratus* larvæ. Mitzmain (1913) working in the Philippines, found *Tabanus striatus* having only three instars, but he makes no mention of the first brief one. Isaac (1924) working with improved technique in India, found *T. striatus*, *rubidus*, and *tenens* molting seven times and that *T. crassus* molted eight times. It is quite likely that most tabanid larvæ molt oftener than was at first supposed.

A characteristic of tabanid larvæ, noted by many who have worked with them, is the variation in their rate of growth. Thus Mitzmain (1913) found 12 day old larvæ of *Tabanus striatus*, reared under exactly the same conditions, varying in length from 3 to 11 mm. Hine (1906) found 25 day old *T. lasiophthalmus* larvæ varied from 3 to 7 mm. Ten day old larvæ of *T. atratus*, reared by the writer, varied from 3 to 6 mm. The older the larvæ grow, the greater the variation becomes. This probably helps to explain the extreme variation in the size of larvæ of a given species collected in the field. Another factor entering there is the difference in the time of egg laying. This may extend over a period of two months.

DURATION OF THE LARVAL STAGE.

In the temperate portions of North America, it is probable that the majority of species and the majority of individuals of a species require only nine or ten months to complete their larval life. However, since the rate of growth is so variable and the oviposition period so extended, there is probably quite a bit of holding over to a second season. This occurs frequently in the laboratory. The writer never succeeded in rearing to the adult stage any larva doing this, but did get a prepupa of *Chrysops carbonarius* from a larva collected over 18 months

previously. Furthermore, when the larva was collected, on July 29th, it was apparently fully grown. A number of other larvæ of this species and one of *Chrysops vittatus* were kept alive fully as long. Cameron (1926) and others, have observed this same phenomenon in their rearing work. If they fail to pupate at the time they should, they will ordinarily pass over to another year. This probably takes place in nature also. The writer collected larvæ of *Chrysops carbonarius* on October 4th, ranging in length from 3 to 15 mm. If they all emerged from the egg the same season, which is probable, one wonders whether they would all be ready to pupate the following May.

Hine, (1906), judging from the rate of growth of the larva of *Tabanus stygius*, felt that it must take two seasons to reach maturity. An adult male of *Tabanus atratus*, reared by the writer, emerged on July 10th from a larva which left the egg on July 18th of the previous year. This, of course, was under laboratory conditions.

LARVAL ACTIVITIES.

Newly hatched larvæ drop to the ground or water and soon disappear from sight, burrowing into the soil or sinking to the bottom of the pond or stream and burrowing into the mud. Certain species have strongly developed tracheal trunks enabling them to float, but as soon as they reach the margin, they hide themselves in the mud or debris.

As is characteristic with larvæ, their chief aim in life is to feed. This they do from the time they leave the egg until winter comes. Then the half grown larvæ hibernate out of the reach of frost, many of them, probably, burrowing into the mud below ponds. They cannot survive in frozen soil, at least if it is moist, as the writer discovered when trying to imitate natural conditions. Active larvæ were collected at the margins of ponds as early as March 19th and as late as December 1st. In the spring, after a more or less brief period of feeding, depending on the species, pupation takes place.

All of this time they are hidden from sight. Occasionally one will find a *Tabanus* larva, especially in the spring, floating on the surface of the water. It is out of its natural environment and will burrow into the soil as soon as it can. One has to dig in the mud, sift out the rubbish and debris of the shore line, dig in rotten logs or search the leaf mold of the forest floor to find them.

Food.—Tabanid larvæ are either carnivorous or saprophagous. Most of the *Tabanus* species are the former. Their prominent mandibles are fitted for piercing and tearing and they use them effectively on earthworms, snails, other insect larvæ and each other. The writer has watched, under the binocular microscope, the feeding of *Tabanus reinwardtii* and *Tabanus atratus* on earthworms. Contact is made by means of a sharp downward thrust of the mandibles. (If one touches the head of a large *Tabanus* larva with a pair of forceps, a distinct click can be heard as the mandibles strike the metal. This downward thrust may be felt as a sharp, stinging prick if it strikes the hand, not sufficient to break the skin, but smarting for several hours after it occurs.) Having secured a hold, by means of a twisting, chewing motion an opening is made in the side of the worm and the whole head thrust in. Then turning first one way and then the other, the fluid contents are sucked out and they can be seen flowing through the pharynx and making the mid-gut red.

Young larvæ of *Tabanus atratus* and other unknown species were fed on crustacea, bits of worm, chironomid larvæ and, best of all, mosquito larvæ. Only these young larvæ were kept in the same receptacle for any length of time and cannibalism was frequently observed. Although the larger larvæ were isolated most of the time, the writer saw no evidence of cannibalism among *Chrysops* species when they were together in close quarters. In fact, the actual attack of a *Chrysops* larva upon another animal was never observed. Fragments of earthworms were found in the jelly glasses, apparently eaten by *C. carbonarius* and *C. celer*. However, the mid-gut of all the *Chrysops* species was rarely red and usually green or black. Cameron (1926) is emphatic in declaring that *Chrysops* larvæ are entirely saprophagous, never feeding on living animal food and refusing it even when starving. It is doubtful if this can be applied to all *Chrysops* species, but certainly most of the food consists of organic matter in the soil, taken from it as it passes through the intestine. Cameron (1926) also found *Tabanus hirtulus* subsisting entirely on dead organic matter and felt that even the admittedly carnivorous species subsisted to some extent on it.

Locomotion.—Tabanid larvæ crawl over surfaces and through the soil by means of a peristaltic movement and telescoping of

the segments. At each contraction wave, the prolegs are invaginated. The prolegs with their rows of recurved bristles are of great value in aiding them to push through the soil. They can move backward nearly as readily as they can forward. Their ability to push through narrow places is very marked and if a large one is held in the hand, it will crawl between the base of the fingers quite easily.

The larger species, with enlarged tracheal trunks enabling them to float, progress slowly, on the surface of the water, by means of their peristaltic action, and rapidly by a strong lashing of the posterior part of the body. The tip of the anal segment is brought forward until it nearly touches the side of the larva and then suddenly straightened, propelling the larva forward its own length or more.

Tropisms.—Probably the strongest of the tropic reactions exhibited by tabanid larvæ is that of a negative phototropism. If placed upon a table in front of a window, they always crawl away from it. Since they are burrowing animals, fond of being entirely in contact with the soil, it may be said that they are postively thigmotropic. They may have a slight positive geotropism but the writer conducted no experiments to determine this accurately. It is quite certainly weaker than its negative phototropism.

THE PREPUPAL PERIOD AND PUPATION.

Twenty-four to forty-eight hours before the final ecdysis, the larva begins the prepupal period. This is characterized chiefly by the projection of the anterior spiracles laterally at the base of the prothorax. They appear as slender white tubes projecting laterally and anteriorly. At the same time, the head is somewhat invaginated and becomes immovably fixed and the thorax becomes slightly swollen. The prepupa is usually quite well developed 48 hours before pupation occurs.

Pupation takes place by the splitting of the integument of the thorax along the mid-dorsal line and the crawling out of the pupa by means of a twisting motion of the abdomen, aided by the bristles surrounding the abdominal segments and by the terminal aster. The mouth parts remain attached to the crumpled exuvium and during the casting of the skin, lie on the venter pointing posteriorly. For successful pupation, the prepupa must be in quite compact soil to hold the exuvium as the pupa comes out.

The Pupa.

EXTERNAL ANATOMY.

The pupa of the Tabanidæ is obtected, the wings, legs and mouthparts being glued to the surface of the body. Anteriorly, it is rather abruptly rounded, while posteriorly, it tapers to a small terminal segment. When first formed it is pale yellowish or greenish; later, it becomes yellowish brown or ferruginous.

Head and Thorax.—These are closely fused. Anteriorly, to each side are the short, rapidly tapering antennæ overlying the eyes. Between these is usually a heavy ridge of chitin, the frontal carina, divided medianly by a notch and sometimes with each side again divided into two parts. Above these lie a pair of setiferous tubercles bearing one or two pairs of setæ. Ventrally, on the fronto-ventral plate, are two pairs of setæ and below these, a pair of short palpal sheaths. Back of the eyes, on the mesothorax, lie the prominent thoracic spiracles, flattened laterally and extending out from the body dorsally, each with an arcuate rima above and behind it. The wing pads reach the second abdominal segment.

Abdomen.—The first abdominal segment lacks an encircling row of spines and definite divisions setting off the lateral areas. Segments two to seven each bear a more or less complete ring of spines near the posterior third. Each segment is divided into a dorsal, two lateral and a ventral area separated by grooves. Each lateral area bears a short, truncate abdominal spiracle. The anal segment may, or may not, bear dorso-lateral and lateral combs of spines. Ventrally, in front of the anus is a row of spines running clear across in the male, but widely broken medianly in the female. The anal region is quite protuberant in the male and much less so in the female. The posterior part of the segment is composed of six heavy, sharp projections forming the pupal aster. This usually consists of two projections dorsally, a larger pair pointing dorso-laterally and another pair pointing ventrally and posteriorly.

DURATION.

The pupal period is relatively short, ranging, roughly, from one to three weeks. The writer found most of the *Chrysops* species emerging in less than two weeks after pupation, ranging from an average of 8 days for *Chrysops carbonarius* to 13 days for *C. vittatus*. *Tabanus* species require a somewhat longer period although one specimen of *T. bicolor* took only ten days and one *T. atratus* did it in 14 days. *Tabanus reinwardtii* averaged 17 days. Webb and Wells (1924) found that *T. punctifer* averaged slightly over 20 days in the pupal state. There is a considerable variation in reared pupæ, so that it is difficult to determine accurately the length of the period.

ACTIVITIES AND EMERGENCE.

The pupa is relatively quiet. At the time of pupation, it comes to lie in a vertical position, an inch or two below the surface of the soil and well above the surface of the water. The writer collected many pupæ of *Chrysops carbonarius* in very compact mud a short distance below the surface. Just before emerging, it crawls up to the surface by means of a twisting motion of the abdomen, projecting most of the thorax above the surface. The pupal case splits along the dorsum of the thorax, the fronto-ventral plate covering the head is pushed forward and the adult emerges.

When the adult first appears, the wings are very much folded and are shorter than the abdomen and the abdomen is enlarged and translucent. Soon the wings begin to enlarge and the meconium is emitted from the anal opening. This is greenish or yellowish in color, at first thick and coming rapidly and then gradually becoming thinner and dropping more slowly. From 20 to 30 minutes after emergence flight for a short distance is possible.

DESCRIPTION OF EARLY STAGES AND BIONOMICS OF SPECIES STUDIED.

Keys to Genera—Immature Stages.

EGGS.

There is no sharp line of differentiation between the eggs of different genera, although, in general, the following key will suffice for the three New York State genera in which the egg is known.

1. Usually in a single tier, lying nearly flat on the surface on which they are placed. (*C. celer* an exception) ..... *Chrysops*
   Laid at an angle to the surface, in two or more tiers ..... 2.
2. Creamy-white at time of hatching ..... *Goniops.*
   Usually dark brown or black at time of hatching ..... *Tabanus.*

LARVÆ.

1. Body club-shaped, the thoracic segments slender, the abdominal segments robust ..... *Goniops.*
   Body tapering anteriorly and posteriorly, not club-shaped ..... 2.
2. Apical antennal segment much longer than the preceding segment; dorsum of thoracic segments nearly as striated as those of abdomen ..... *Chrysops.*
   Apical antennal segment not longer, usually much shorter, than the preceding segment; dorsal areas smooth or striated, but those of thorax nearly or quite free from striæ ..... *Tabanus.*

PUPÆ.

1. One spine on each side of median line on dorsum of each abdominal segment much stronger than the others in the series ..... *Goniops.*
   Spines of each series either of an almost uniform strength or at least no two spines conspicuously stronger than the others ..... 2.

2. Antennæ surpassing adjacent margin of head; head with two bristles from each dorsal tubercle.....*Chrysops.*
Antennæ not projecting beyond lateral margin of head; head with one bristle from each dorsal tubercle.....*Tabanus.*

Chrysops Meigen.

During the course of this study, the following species of *Chrysops* were reared from the larval to the adult stage:—*callidus, carbonarius, celer, cuclux, indus, moechus, montanus, niger, striatus, vittatus* and *wiedemanni.*

Key to Mature Larvæ of Chrysops.

This key includes those species the writer has reared and several of those New York State species on which Cameron (1926) worked, the characters of the later being taken from his descriptions. It must be used with caution as the pubescent areas are subject to even more variation than the color areas in the adults. Those species in the group possessing a spine on the siphon are particularly difficult to separate.

1. Siphon without a terminal, exsertile spine..... 2.
Siphon with a terminal, exsertile spine..... 5.
2. Anal segment slender, prolegs of the pre-anal segment elongate; pre-anal segment dorsally with some pubescence..... 3.
Anal segment not very slender; prolegs short and rounded; pre-anal segment non-pubescent dorsally except for a very narrow pubescence along the dorso-lateral line..... 4.
3. Dorsum of pre-anal segment distinctly non-pubescent discally. (Fig. 5), *cuclux.*
Dorsum of pre-anal segment rather uniformly faintly pubescent. (Fig. 6), *moechus.*
4. Anal segment with one or two pairs of prominent dorso-lateral spots; body usually brownish green in color.....*carbonarius.*
Anal segment with only one, small, dorso-lateral spot; body usually whitish or creamy in color.....*vittatus.*
5. Posterior ring of the anal segment, dorsally, covering one-third or less of the segment..... 6.
Posterior ring of the anal segment, dorsally, covering more than one-third of the segment..... 9.
6. Anal segment with one or two large dorso-lateral spots; posterior ring joined widely to the anal pubescence..... 7.
Two or three small dorso-lateral spots; posterior ring not joined broadly to the anal pubescence..... 8.
7. Often two pairs of dorso-lateral spots on the anal segment; tracheal trunks in the 6th and 7th segments contrasting black and opaque white.....*celer.*
One large mitten-shaped pair of dorso-lateral spots on anal segment...*mitis.*
8. Elongate dorso-lateral spots on anal segment usually joined to the posterior ring; the more dorsal of the two smaller dorso-lateral spots very small and slender.....*striatus.*
Elongate dorso-lateral spots usually free from the posterior ring; the more dorsal of the remaining spots as large or larger than the other, round.....*excitans.*
9. Anal segment with a pair of anterior dorso-lateral projections from the posterior ring.....10.
No anterior dorso-lateral projections or spots; a pair of large, clear, dorso-lateral areas in the posterior ring.....*montanus.*

10. Anterior projections from the posterior ring long and slender.....*moerens.*
    Anterior projections short and rounded.....11.
11. Anal segment with no isolated pubescent spots anterior to the posterior ring.....*callidus.*
    One or more pairs of dorso-lateral spots anterior to the posterior ring....12.
12. Anal segment with two projections from the posterior ring between the dorsum and the anus.....*niger.*
    Anal segment with only one, dorso-lateral projection.....13.
13. Dorso-lateral projections from the posterior ring not abruptly narrowed apically; dorso-lateral spots large, lying close between the dorso-lateral projection and the widened lateral pubescence.....*wiedemanni.*
    Dorso-lateral projections abruptly narrowed apically.....*indus.*

Chrysops callidus Osten-Sacken.

Mature larva.—Length, (living), 12–14 mm. Yellowish white or greenish; annuli brown, quite distinct; anal segment rather short and rounded; posterior pubescent ring quite broad, covering nearly half the segment dorsally and taking in the anus; a narrow anterior ring dorsally; a pair of dorso-lateral lobes anteriorly from the posterior ring and a pair of minute dorso-lateral clear spots in the posterior ring. Siphon Short, striated, with a short spine.

Pupa.—Length, 12–13 mm. The frontal carinæ prominent, rounded, the median pair divided by a deep cleft. Pre-anal fringe with about fifteen spines in the male and five or six on each side in the female. Prongs of the aster large and sharply pointed.

Range.—Ontario, Florida, Ohio, Kansas, Louisiana.

This species is abundant throughout the State from early June to early August. Occasionally, it is collected in May and late into August. Ithaca—June 16th to August 6th.

Hine, (1903), described in some detail the oviposition in this species, and Marchand, (1917), described the egg and the young larva.

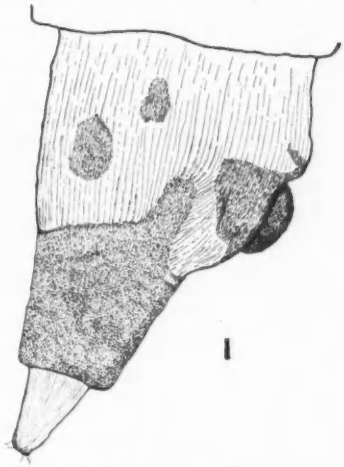
Only three larvæ were collected and positively identified during the course of this study. One was found in mud and decayed leaves of a small pond in Salisbury, Conn., the second at the margin of Dryden Pond, near Ithaca, and the third in a swamp near Ithaca. All three were found in quite unshaded localities.

As the prepupal stage was not observed, the date of pupation as given in the following table may not be accurate. It is merely the date on which the pupa was first seen. The third one emerged during the writer's absence from the laboratory from June 24th to July 1.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 4, 1927	L 13 mm.	.....	April 28	May 7	♀
May 9, 1928	L	.....	May 27	June 4	♀
June 10, 1927	L	.....	June 17	June 24	
				July 1	♂

Chrysops carbonarius Walker.
(Figures 1, 2 and 4.)

Mature Larva.—Length, (living), 12–15 mm., (Preserved), 20–21 mm. Width, 2.5 mm. Body yellowish brown, usually with a distinct greenish tinge when living, making it olive-green; pubescence light brown; annuli only slightly darker than the integument; head reddish brown; pharyngeal capsule dark brown to black. Prothorax narrowly pubescent anteriorly, this ring being narrowest ventrally and widest laterally; posterior pubescent projections from this ring dorso-laterally, ventro-laterally, and mid-ventrally; the dorso-lateral pair extend back from the anterior margin about two-thirds the length of the segment, widen



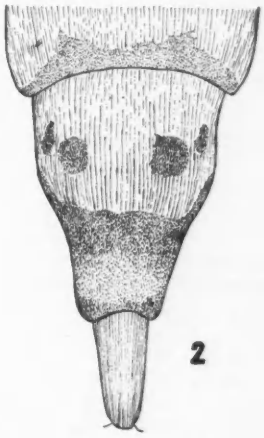


Fig. 1. *Chrysops carbonarius* Walk. Lateral view of anal segment and siphon of larva. Magnified 30 diameters.

Fig. 2. *Chrysops carbonarius* Walk. Dorsal view of anal segment and siphon of larva. Magnified 21 diameters.

slightly posteriorly and are divided by a narrow, longitudinal hyaline line; ventro-lateral pair slender and somewhat shorter; mid-ventral line as long as the dorso-lateral pair and very slender. Mesothorax: narrow anterior annulus with posterior projections dorso-laterally, laterally, and two pairs ventro-laterally; the dorso-lateral pair is about one-third the length of the segment with its lateral margin along the dorso-lateral line and the dorsal margins nearly meeting mid-dorsally. Other projections longer, very slender and faint. Metathorax: slightly wider annulus with short, dorso-lateral projections forming a gentle curve to the anterior margin of the dorsal area and very short points at the same places as in the mesothorax. All three thoracic segments

striated throughout becoming progressively coarser from prothorax to metathorax. On each segment a narrow posterior band of very fine striation. Ventral bristles short and black. Abdomen: segments 1–7 dorsally with an anterior band of pubescence partially divided transversely by a non-pubescent area. On the first segment this transverse division is slender and nearly straight, reaching to the lateral prolegs and often broken in places by pubescence. As one proceeds posteriorly, the annuli become wider and the transverse non-pubescent area becomes shorter and crescentic with the curve anterior. Dorso-laterally, there is a small projection posteriorly from the annulus, becoming more prominent on the posterior segments, but never very long; sixth and seventh segments with a posterior annulus, the seventh with a small, pointed, dorso-lateral projection anteriorly. Lateral prolegs with fine brownish setæ and patches of pubescence dorsally and ventrally to them. Ventral pair of prolegs with brownish setæ and an irregular band of pubescence around and betwen them. On the anterior segments, the dorsal, lateral and ventral pubescent areas are joined, forming a complete ring, while on the posterior segments, this ring is broken above and below the lateral prolegs. Prolegs of moderate length. Anal segment broad at the base, tapering at the apex; dorsally with one or two pairs of prominent dorso-lateral pubescent spots; if one, it is irregular in shape, if two, the dorsal-posterior pair is larger than the more lateral, anterior pair; posterior ring about one-third the length of the segment, sometimes narrowly joined mid-ventrally to the pubescence which surrounds and covers the anus; anal and posterior pubescence nearly, or completely, joined laterally by dorsal projections of the anal pubescence meeting lateral anterior projections of the posterior ring. Integument of the abdomen striate throughout. Siphon of moderate length without pubescence or a spine at the tip; very finely striated throughout, often with hairs near the tip. Tracheal trunks quite slender, shining white to the middle of the seventh abdominal segment, posterior to which they become gray. Graber's organ usually with four pairs of black bodies.

Pupa.—Length, 11–13 mm. Width at thorax, 2.5 mm. Frontal teeth consisting of a pair of transverse carinæ flanked by a pair of small projections. The inner carinæ are quite prominent near the mid-ventral line. Rima of the prothoracic spiracle with a posterior hook which is absent in the male. Pre-anal spines in the female three or four on either side. In the male, a fringe of 12 to 16, not extending as far laterally as in the female. Pupal aster: dorsal prongs short, pointed, extending nearly parallel to each other, upward; lateral pair long and slender with slightly recurved tips, extending up and back; ventral pair intermediate in size, sharply pointed and projecting down and back. Abdominal spiracles short, dark brown, projecting somewhat posteriorly.

Range.—Canada, Maine, North Carolina, Wyoming, Colorado.

This is a common species throughout the State, appearing in the latter half of May and throughout June in the vicinity of water and woods. It is the first *Chrysops* to appear in this region. Ithaca—May 18th to June 25th. The females readily attack man and cattle.

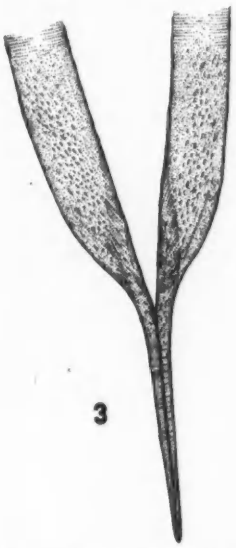


Fig. 3. *Chrysops celer* O.-S. Dorsal view of posterior spiracle dissected from larva. Magnified 52 diameters.

Fig. 4. *Chrysops carbonarius* Walk. Dorsal view of posterior spiracle dissected from larva. Posterior end is turned to the left. Magnified 118 diameter.

The larvæ are found in mud among dead leaves and sticks, often under the water, along the margins of streams and ponds. It is, by far, the most frequently encountered tabanid larva in this region. Over 300 larvæ and pupæ of this species were collected during the course of this study, the former ranging in size from 5 mm. to mature larvæ of 12 to 15 mm. They were collected in every month from March to November, being most abundant in April and May, rather scarce in June and again very abundant in the fall. The greatest variation in size is found in the fall when all sizes may be collected at one time and place. They apparently fed on earthworms in the laboratory

as many earthworms died, disappeared, or were found in a fragmentary condition in the jars, although the act of feeding was not observed. As is shown in the following table, several larvæ, apparently mature when collected, have remained alive and unchanged through two winters.

Pupæ were found in the field in compact mud, several feet back from the water, and just below the surface, from May 10th to May 26th. In the laboratory, they pupated from October to June with the greatest number in March and May. Those that pupated in March had been kept over the winter in the laboratory and were responding to the somewhat higher temperature, while those that pupated in May were collected the same spring and were not influenced very much by the change of environment. Larvæ collected in the field in the prepupal stage emerged eight days after pupation. The following table gives life history data on some of the larvæ reared. It is interesting to note that prepupæ were collected on May 12th in two successive years, the only date on which they were collected.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
March 19, 1927	L	March 31	April 2	April 11	♀
April 14, 1927	L	April 23	April 26	May 2	♀
" 10, 1928	L	" 24	" 26	" 3	♀
" 10, "	L	" 22	" 24	" 1	♀
" 10, "	L	" 25	" 27	" 4	♀
" 10, "	L	" 27	" 28	" 5	♀
" 10, "	L	" 21	" 22	April 29	♂
" 10, "	L	May 3	May 5	May 12	♀
May 12, 1927	Pp	" 12	" 14	" 22	♀
" 12, "	Pp	" 12	" 14	" 22	♀
" 12, "	Pp	" 12	" 14	" 21	♀
" 3, 1928	L	" 10	" 11	" 19	♀
" 4, "	L	" 8	" 10	" 17	♀
" 4, "	L	" 10	" 11	" 19	♀
" 12, "	Pp	" 12	" 13	" 22	♀
July 7, 1927	L 13 mm.	Died April 8, 1929.			
" 7, "	L 13 mm.	Died March 19, 1929.			
" 7, "	L 15 mm.	Died May 20, 1929.			
" 16, "	L 13 mm.		March 26	April 5	♀
" 16, "	L 14 mm.		April 17	" 21	♂
" 29, "	L 15 mm.	April 10, 1929. Died April 11.			
August 30, 1926	L	Feb. 12	Feb. 17	March 3	♀
" 30, "	L	" 26	March 2	" 11	♂
" 30, "	L	March 12	" 17	" 24	♀
Sept. 24, "	L	Feb. 26	" 3	" 13	♀
" 1, 1927	L 13 mm.		Oct. 27	Oct. 31	♂
Oct. 6, 1926	L	Feb. 19	Feb. 22	March 6	♀
" 6, "	L	March 12	March 14	" 23	♂

Chrysops celer Osten-Sacken.
(Figures 3 and 9.)

Mature Larva.—Length, (living), 14–16 mm., (preserved), 20–22 mm. Width, 2.5–3 mm. Body pale, creamy white; pubescence of anal segment dark brown; annuli pale brown; head brown, the slender anterior portion of the pharyngeal capsule yellowish-orange, the wider posterior portion dark brown. Markings of the thoracic and first seven abdominal segments much like those of *C. carbonarius* but slightly paler and less extensive. The dorso-lateral projections of the prothorax are smaller. Ventral thoracic bristles extremely slender. Annuli of abdominal segments very pale and indistinct. Striæ moderately coarse, becoming coarser posteriorly. The posterior ring of the seventh abdominal segment lacks definite, anterior projecting, dorso-lateral lines. Anal segment broad basally and constricts rather abruptly to form a narrow apex. Dorsally, the posterior pubescent ring is confined to this narrow portion, about one-third the length of the segment, and it is usually slightly curved forward in the center; laterally and ventrally, it becomes much wider, covering the anus. There is sometimes left a pair of ventro-lateral clear spots in the wide ring. The dorso-lateral region may contain two pairs of distinct longitudinal pubescent spots, the lateral one slightly smaller and anterior; these spots may be fused forming one large pair; this large pair may be joined anteriorly to the lateral pubescence or it may also be joined posteriorly to the posterior ring, leaving only a small clear area between it and the lateral pubescence. There is an irregular band, or a pair of pubescent spots dorsally along the anterior margin and this is often joined to the dorso-lateral spots. Prolegs quite short. Siphon rather short, heavy, without pubescence and very finely striated, often with a few hairs at tip. A very strong exesrtile spine is present, reddish in color. Tracheal trunks rather heavy and white except for the posterior part. From the region of the posterior transverse trunk in the 7th abdominal segment back to the middle of the anal segment, the tracheal trunks are dark brown or nearly black; from this point, to the joining of the two trunks to form the spine, they are opaque, creamy white. This character can be seen most easily in the living larva and it is very distinctive. Graber's organ usually with four pairs of bodies. The combination of the light color, the markings of the anal segment, the spine from the siphon and the color of the tracheal trunks will serve to identify this species.

Pupa.—Length, 12–14 mm. Median frontal carinæ only slightly protruding, broad, rounded; lateral frontal carinæ very small. Preanal fringe in male of fifteen or more spines, in the female usually with four spines on each side. Aster with large, sharp prongs.

Range.—Ontario, Quebec, Ohio, North Carolina.

This species is very similar in habits to *carbonarius* and is likewise one of the earlier forms. It is moderately abundant throughout the State from late May to early July. Ithaca—May 30th to June 29th. It attacks man and cattle readily.

Hine (1903a) observed oviposition in this species and found that it placed its eggs in layers, one above the other, as in *Tabanus*.

The larvæ are found in the muddy margins of ponds and sluggish woodland streams among decaying vegetation. Over sixty larvæ and one pupa were collected. They were found from March to November, the majority of them being collected in May and July. A number of them were lost, as they are very active and crawled out of the jelly glasses on which the covers were not secure. They apparently fed on earthworms put in the jars.

On May 12th, a prepupa was collected in friable mud some distance from the water, exactly a year later two more were collected in the same place, and on June 19th a pupa was found. Pupation occurred in the laboratory from April 13th to June 19th, most of it occurring in May. The average length of the pupal period, in the laboratory, was 11 days. In no case was it less than 8 days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
March 26, 1927	L	April 10	April 13	April 21	♀
April 6, "	L	" 22	" 24	May 3	♀
May 12, "	Pp	May 12	May 14	" 22	♂
" 12, 1928	Pp	" 12	" 16	" 27	♂
" 12, "	Pp	" 12	" 13	" 23	♂
" 12, "	L	" 22	" 29	June 10	♀
" 12, "	L	" 13	" 16	May 27	♂
June 19, "	P		June 19	June 26	♀

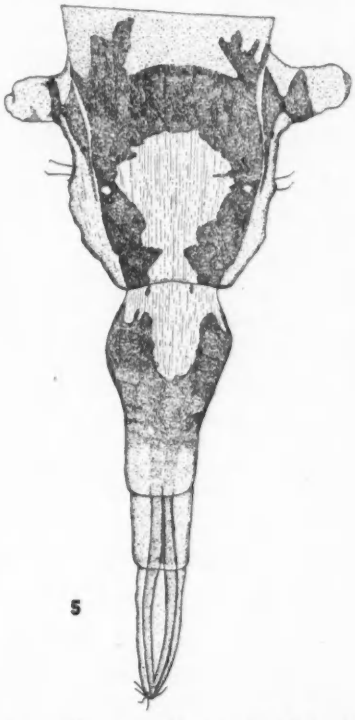
Chrysops cuclux Whitney.

(Figure 5.)

Mature Larva.—Length, (living), 12–14 mm., (preserved), 17–19 mm. General color yellowish brown; pubescence rather dark brown; head pale brown, the pharyngeal capsule black. Thoracic segments with anterior pubescent annuli and projections posteriorly from it along the dorso-lateral, lateral, ventro-lateral and median lines as in *carbonarius* and others of this group; the dorso-lateral spots on the prothorax elongate and distinct; annuli of the abdominal segments becoming wider posteriorly; sixth abdominal segment with little, if any, pubescence dorsally; pre-anal segment pubescent dorsally except for a distinct clear area discally; the dorso-lateral pubescence on this segment much wider than it is ever found in *carbonarius*. Lateral and ventral prolegs long, projecting at right angles, the posterior pairs longest and lacking setæ; these are nearly as long as in *moechus* but in crawling, they are pulled nearly directly in and not bent backward. Anal segment long and slender, with a wide posterior ring nearly covering the anus; a pair of dorso-lateral projections meeting the dorso-lateral

pubescence of the pre-anal segment. Siphon long and slender with a slight pubescence and no exsertile spine; tracheal trunks very slender, distinctly separated in the siphon up to the tip. Graber's organ compact with usually four pairs of black bodies.

The larva of this species can be readily determined by the markings of the pre-anal segment and the shape of the prolegs and anal segment.



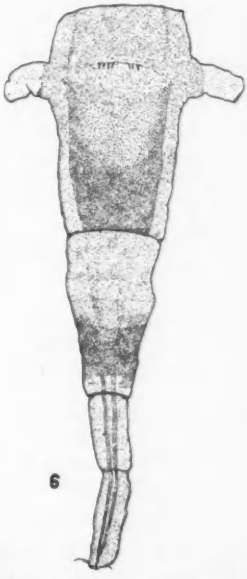


Fig. 5. *Chrysops cuclux* Whitn. Dorsal view of pre-anal and anal segments and of siphon of larva. Magnified 20 diameters.

Fig. 6. *Chrysops moechus* O.-S. Dorsal view of pre-anal and anal segments and of siphon of larva. Magnified 15 diameters.

Pupa.—Female: Length, 12 mm. Median frontal carinæ rather prominent, narrow; lateral frontal carinæ small. Pre-anal spines four or five on each side; aster with a broad median surface, the prongs large, the dorsal and lateral prongs on each side somewhat joined at the base; apices sharp, sligh tly curved.

Range.—Ontario, Nova Scotia, New York, Massachusetts.

This species is moderately abundant in May and June over most of the State. It has been collected at Ithaca, but not by the writer.

Larvæ were collected by month, as follows: May, 1; July, 9; August, 3; September, 11; October, 2; November, 1; a total of 27. Only one of these has emerged at the time this is written, but the larva is so distinctive that identification is not apt to be incorrect. They were all found in the very wet mud of sluggish streams or at the margin of artificial ponds.

The one specimen that completed its life cycle was collected on May 4th, found to have pupated on May 26th, and emerged June first, a female.

Chrysops indus Osten-Sacken.

Mature Larva.—Length, (living), 13–14 mm. General color pale, yellowish white; annuli pale brown, indistinct; striæ of thorax and abdomen quite distinct. Prolegs short, rounded, provided with short setæ. Anal segment with a rather broad posterior pubescent ring with a pair of slender, dorso-lateral projections narrowing apically, and a pair of spots anterior and lateral to them; pubescence covering the anus ventrally; a pair of minute, dorso-lateral hyaline spots in the posterior ring. Siphon short and rounded with a very short spine. Tracheal trunks heavy.

Pupa.—Length, 12–14 mm. Frontal carinæ quite prominent, the median pair rather broad and separated by a distinct cleft, the lateral pair smaller and pointing somewhat laterally. Pre-anal fringe in female with four long spines on each side; in the male, about 15 in the entire row. Aster with large prongs; dorsal pair distinctly separated at the base, and curved laterally; lateral pair large and close to the dorsal pair; the ventral pair pointing somewhat to the sides.

Range.—Ontario, Quebec, Iowa, New York, New Jersey.

This species appears early in June throughout most of the State and continues through to late July or early August. It is one of the most frequently encountered species during June and July, and is a persistent pest of man, cattle and horses. Ithaca—June 14th to July 22nd.

Hine (1903a) observed this species ovipositing along the margin of a small lake, the eggs being placed in single layers on grass blades over the water. He collected males near where the females were ovipositing and on the flowers of *Cornus*.

This is one of the typical semi-aquatic species in the larval state. The writer has reared four males and one female of this species from larvæ, and one male from a pupa collected in

the field. The larvæ were all found in the mud at the margins of a small pond and a backwater pool.

One pupa was collected in the mud of the outlet of Green Lake, near Tully, N. Y., on June 12th and on June 18th a male emerged. As may be seen in the following table, pupation in the laboratory occurred late in May and early in June and the pupal period averaged about 12 days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 22, 1926	L			June 13	♀
May 10, 1927	L	May 24	May 29	" 10	♂
" 10, "	L	" 31	June 2	" 13	♂
" 10, "	L	" 16	May 18	" 1	♂
June 12, "	P		June 12	" 18	♂

Chrysops moechus Osten-Sacken.

(Figure 6.)

Mature Larva.—Length, (living), 14–15 mm., (preserved), 17–18 mm. Width, 1.5 mm. A very slender larva with prominent prolegs. Body pale yellowish or greenish brown, becoming darker on the posterior segments. Head light brown, the pharyngeal capsule dark brown. Thoracic segments with an irregular anterior band of faint pubescence, widest on the prothorax where it covers about half the segment and narrower on the other segments. Striæ of the thoracic segments very fine. Abdomen: first to fourth segments usually clear, the annuli becoming wider posteriorly; fifth segment dorsally with only a large discal spot clear, the rest pubescence; sixth and seventh nearly uniformly covered with fine pubescence; no distinct clear patch discally on the dorsum of the seventh segment. Striæ of the abdomen very fine; dorsal prolegs fused into one rather prominent transverse ridge, the lateral prolegs very prominent becoming longer posteriorly and extending at right angles; when alive, they bend backward in crawling; ventral pair of prolegs also prominent and close together; the setæ which are abundant on the shorter anterior prolegs are lacking on the larger posterior prolegs. Anal segment long and slender, very narrow and attenuated posteriorly; fine pubescence over the whole segment, this being thicker in a band around the middle of the segment just posterior to the anus and at the region of the narrowing of the segment. Siphon long and slender, faintly pubescent, without a spine but often with long hairs. Tracheal trunks extremely slender, white anteriorly to the anal segment and brown posteriorly, distinctly separated in the siphon until they reach the tip. Graber's organ with three or four bodies.

Pupa.—Length, 11–12 mm. Median carinæ of the front of the head prominent, angular, the lateral pair smaller but also distinctly projecting. Pre-anal fringe in the female consisting of three or four spines on each side and in the male of about 12 spines in all. Pupal aster with a rather broad median part and short spines.

Range.—Michigan, New York, Ohio, Virginia, Georgia.

This species is moderately abundant throughout the State south of the Adirondacks in late June and early July. Ithaca—July 2 to 30th. Hine, (1903), observed the females ovipositing on foliage overhanging a mill race on June 4th.

Twelve larvæ were collected in May of 1927 and May, June, July and September of 1928. They were all found in very wet mud, often under the water, at the margin of a small artificial lake and at the margin of a muddy backwater above a dam. They are very active larvæ. No pupæ or prepupæ were collected in the field. Pupation occurred in the laboratory the last week of May with one exception in June. The length of the pupal period was very irregular, ranging from 10 to 15 days. The following table gives the life history data of those that emerged.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 7, 1927	L 16 mm.		May 31	June 8	♀
" 7, "	L 16 mm.		" 31	" 6	♀
" 8, "	L	May 25	" 27	" 6	♂
" 4, 1928	L	" 25	" 29	" 11	♂
June 19, "	L		June 30	July 9	♂

Chrysops montanus Osten-Sacken.

Mature Larva.—Length, (living), 12–14 mm., (preserved), 14–16 mm. Very pale yellowish white; annuli very little darker; head capsule brownish; prothorax very finely striated; rest of thorax and abdomen striate, the striæ wider apart anteriorly (except for prothorax) than posteriorly. Pre-anal segment usually with pubescence along the dorso-lateral lines. Abdominal prolegs rather short, rounded. Anal segment rather short and rounded, a wide posterior pubescent ring reaching to the front of the anus, in which lie a pair of large dorso-lateral clear spots and often a pair of large ventro-lateral clear spots. Siphon rather short and rounded, striate, with a prominent, exsertile spine.

Pupa.—Length, 10–12 mm. Median frontal carinæ large, wider medianly than laterally and separated by a very narrow cleft; lateral carinæ also large and usually distinctly separated from the median pair. Pre-anal fringe in female with about four spines on each side somewhat joined basally in a protuberance; in the male, 12 to 15 in all. Aster with large prongs, the two upper pairs with the tips curved downward slightly; the lower pair very acutely pointed.

Range.—Quebec, Vermont, Ohio, Illinois, Maryland.

This species is rarely found except in the vicinity of lakes or ponds, at which places it may become quite abundant. It has not been recorded from Ithaca. On July 7th, the writer

collected one at Spencer Lake and on August 4th, four at Cayuta Lake, both about 14 miles from Ithaca. At the latter place, they flew to our boat when some distance from the shore, to attack us. It has been collected throughout the State from late June to early August. Hine (1903a) also found it partial to lakes and collected males by sweeping plants along the margin of a lake.

The larvæ were collected near North Fairhaven, N. Y., on the shore of a small pond close to Lake Ontario. The pond was separated from the lake by a narrow strip of beach and the larvæ were found right at the water's edge in very coarse sand saturated with water. Eighteen were collected in less than ten minutes and without moving from one spot. The next day, on returning to the laboratory, it was found that several of them had formed prepupæ. On June 24th, the writer was called away from the laboratory, at which time most of them had pupated and on returning July 1st, all except one had emerged, and that emerged the following day. The pupal period was, therefore, close to eight days. The following table gives the life history data on those that emerged. The date of emergence is not strictly accurate as some may have emerged previous to this date.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 15, 1927	L		June 16	July 1	♂
" 15, "	L	June 16	" 18	" 1	♂
" 15, "	L	" 16	" 19	" 1	♂
" 15, "	L	" 18	" 21	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L	June 23		" 2	♀

Chrysops niger Macquart.
(Figure 7.)

Mature Larva.—Length, (living), 10–11 mm., (preserved), 13–14 mm. Width, 1.8 mm. A pale yellowish white larva; pubescence brown; head pale, the skeletal portion of the pharyngeal capsule darker brown. Prothorax with anterior half finely pubescent; striæ fine. Mesothorax with a rather narrow ring of pubescence, wider laterally; the striæ fine

laterally, coarse dorsally and ventrally. Metathorax much like the mesothorax ventral setæ on the thoracic segments very fine. Abdomen: annuli indistinct, dorsally consisting of a double transverse row of scattered pubescence and setæ becoming farther divided posteriorly; striæ of abdomen coarse dorsally and ventrally, fine laterally; prolegs rather short, clothed with light setæ, the dorsal pair joined in one transverse ridge. Anal segment short, stout, sub-conical; scattered pubescence along the anterior margin, dorsally; posterior ring narrowest dorsally covering the narrow part of the segment; ventrally, it reaches the anus and joins the anal pubescence the full width of the anus;

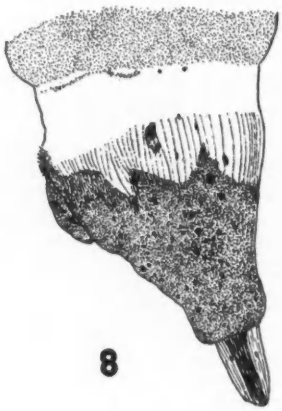


Fig. 7. *Chrysops niger* Macq. Lateral view of anal segment and siphon of larva. Magnified 44 diameters.

Fig. 8. *Chrysops vittatus* Wied. Lateral view of anal segment and siphon of larva. Magnified 32 diameters.

dorso-laterally, a pair of prominent anterior projections, often of darker pubescence; just anterior and lateral to this, a round, dorso-lateral spot; these two are often joined and the connection between the projection and the posterior ring broken, giving a hook-shaped dorso-lateral spot; laterally, there is a prominent anterior projection, often swollen at the end and separated from the anal pubescence by a distinct posterior projection of the clear area; setæ very prominent around the apex of the anal segment and to either side of the anus. Siphon heavy, finely striated, faintly pubescent at base with a prominent, slender spine. Tracheal trunks heavy, white. Graber's organ with three or four pairs of bodies.

This species is much like *C. wiedemanni* Krŏb. but the posterior ring is separated from the anal pubescence laterally and there are no light dorso-lateral spots in the posterior ring.

Pupa.—Length, 11–12 mm. Frontal carinæ absent, the frontal plate rounded with only the slightest indication of a pair of protuberances. Four or five spines to either side in the pre-anal fringe of the female; male with about 15 spines in the whole row. Aster considerably wider transversely than dorso-ventrally; the dorsal prongs run parallel to each other, the lateral pair extend widely to the sides, and the ventral pair are widely separated; all the prongs are separated from each other to some extent. The width of the pupal aster and the non-carinated front serve to distinguish this species from any other *Chrysops* pupa of which the writer knows.

Range.—Nova Scotia, Maine, New York, Illinois, Tennessee, Georgia, Virginia.

A common species throughout the State from late May to early August. It appears shortly after *carbonarius* and attacks man, cattle and horses. Ithaca—May 30th to July 10th.

The larvæ of this species are found in wet mud usually in unshaded places. They were collected from May 13th to June 6th, eight of which were found in a boggy meadow fed by springs, one at the margin of a swamp by a roadside, and another in a creek bank.

Pupation occurred in the laboratory from May 18th to June 12th. The pupal period is long, about 14 days, and one remained as a pupa 17 days. The following table shows the variation, although the pre-pupal period was noted in only three. The pupal period of the others might have been even longer.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L	May 27	May 29	June 11	♀
" 13, "	L		" 25	" 8	♂
" 13, "	L		" 27	" 7	♂
" 13, "	L		June 3	" 10	♀
" 13, "	L	May 14	May 18	" 1	♂
" 13, "	L		" 22	" 8	♀
" 27, "	L	June 8	June 12	" 26	♀
June 6, 1927	L		" 11	" 19	♀

Chrysops striatus Osten-Sacken.

Mature Larva.—Length, (living), 12–13 mm. Pale yellowish or greenish-white; head and pharyngeal capsule pale brown; annuli pale and rather indistinct. Prolegs short with fine setæ. Anal segment with a narrow posterior pubescent ring and markings as follows: (1) a pair of spots, joined to each other, close to the median line at the extreme base of the segment; (2) a pair of very small linear spots slightly more laterally and half way between the base and the apex of the segment; (3) nearly laterally, somewhat anterior to the latter spots, a pair of larger spots, somewhat linear and pointing antero-medianly; (4) a pair

of slender lateral lines running forward past the widest part of the segment and loosely joined to the posterior ring; (5) a spot to each side of the anus; anus with a slight ring of pubescence around it; the anal pubescence not joined to the posterior ring. Tracheal trunks large. Siphon short, striated, with a very short spine.

Pupa.—Length, 10–12 mm. Median frontal carinæ of moderate size, rounded; lateral pair scarcely visible. Pre-anal fringe in the female with five long spines to either side. Aster in the female with all the prongs very sharp, the dorsal pair close together, the ventral pair pointing nearly straight back; in the male, the dorsal and lateral pairs have slightly recurved tips and the prongs of the dorsal pair are quite widely separated.

Range.—Ontario, Maine, Illinois, New Jersey, Mexico, Louisiana.

This species is found throughout the State from late June to late August, being particularly abundant along the shore of Lake Ontario. It is only infrequently encountered in the vicinity of Ithaca, the writer having collected only three adults during the course of this study, in the latter part of July.

Three larvæ of this species were collected and reared to the adult state. They were all collected in mud, one near Canaan, Conn., and two others at Big Lake, Tully, N. Y. The following table gives the life history, as far as it was recorded, of these three.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 30, 1927	L 13 mm.	June 12	June 13	June 19	♀
" 12, 1928	L		" 26	" 28	♂
" 12, "	L 12 mm.		" 29	" 30	♂

Chrysops vittatus Wiedemann.

(Figure 8.)

Mature Larva.—Length, (living), 10–12 mm., (preserved), 16–17 mm. Width, 1.6 mm. Body creamy white, the annular pubescence very pale anteriorly, becoming slightly darker posteriorly; anal pubescence dark brown. Head and posterior part of the pharyngeal capsule brown. Prothorax finely striated, extremely so laterally; pubescence covering about three-fourths of the segment anteriorly, being slightly narrower dorsally. Mesothorax with anterior portion of the clear area coarsely striated, posterior part finely striated; dorsally, the pubescence is very narrow at the median line, running back to about one-half the length of the segment at the dorso-lateral line; laterally, the pubescent area is slightly narrower than the widest part of the dorsal pubescent area and is fairly uniform in length the width of the area; ventrally, the pubescent area is still narrower with a constriction each side of the median line leaving a rounded swelling medianly.

Striæ and the pubescent pattern of metathorax as in the mesothorax, but as the segment is larger in diameter, the dorsal and ventral angles are not as acute; ventral setæ very fine, black, those of the prothorax in the pubescent area. Abdomen: annuli very pale, the dorsal transverse non-pubescent area becoming wider and shorter posteriorly; the dorsal prolegs fused into one, slightly raised transverse ridge; lateral and ventral prolegs moderately prominent, clothed with short, pale setæ. Anal segment with the posterior, slender part elongate; the dark brown posterior ring covers about one-half the segment middorsally with a pair of triangular anterior projections dorso-laterally; ventrally, it covers the anal region; often a pair of small linear spots just lateral and anterior to the triangular projections of the posterior part of the posterior ring; a narrow anterior annulus dorsally; the narrow posterior part of the posterior ring often paler than the anterior part; siphon very slender, non-pubescent, finely striated, without spine but often with a few hairs near the tip. Tracheal trunks slender, pale brown in the anal segment and siphon, the rest white. Graber's organ usually with four pairs of bodies.

Pupa.—Length, 10–12 mm. Frontal carinæ not very prominent, the median and lateral pairs both rounded, the latter somewhat smaller. Pre-anal fringe with four or five spines on each side in the female; in the male, about 15 spines all together. Aster; dorsal prongs small, sharply pointed; lateral pair largest, slightly recurved.

Range.—Eastern North America from Quebec to Florida and west to Kansas and Iowa.

This is the most abundant *Chrysops* in the vicinity of Ithaca and it causes more discomfort to one walking in the woods than all the other species combined. It also is very troublesome to cattle and horses. Hine, (1903a), writes, "The most abundant and widespread species in this section. The females are troublesome to stock and are commonly observed on horses and cattle with their abdomens filled with blood. The males have been procured along the margins of ponds and on various kinds of flowers." It is found throughout the state from the latter part of June through August. At Ithaca, it is particularly abundant in July. Ithaca—June 25th to August 29th.

The larvæ are found in wet mud at the margins of ponds and streams. About fifty were collected during the course of this study in a number of different places in the vicinity of Ithaca and in northwestern Connecticut. The majority of places were quite shaded, but several were not. They were found in every month from May to November, being most abundant in May, August and September.

The larva of this species was described by Hart in 1895, the first *Chrysops* larva to be described. He found it in some abundance in the mud and matted vegetation of a weedy, swampy little stream. His description of the larva accords with the specimens the writer has obtained, with one exception. He wrote, "Respiratory tube whitish, *spine sometimes projecting.*" We have carefully examined all the larvæ and larval exuviæ obtained and have found them all to possess the compressed type of posterior spiracle joined firmly to the integument at the end of the siphon.

Pupation in the laboratory occurred from March to July, most of it in late May and June. One prepupa was collected in the field on May 29th and a male emerged from it June 7th. The average pupal period in the laboratory was 13 days, with a range of from 8 to 18 days. This variation did not correspond to variation in temperature or in the time of pupation. The following table gives the rearing data of those larvæ in which the prepupal stage was noted and of several others of interest.

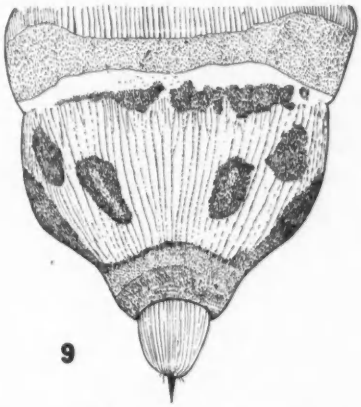
Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 5, 1926	L	June 15	June 19	July 3	♂
" 5, "	L	" 19	" 21	" 4	♂
" 29, 1927	Pp	May 29	May 31	June 7	♂
" 4, 1928	L	June 1	June 2	" 14	♀
" 12, "	L	" 2	" 3	" 16	♀
" 13, "	L	" 1	" 2	" 16	♀
" 13, "	L	May 29	" 1	" 13	♂
" 13, "	P		May 27	" 11	♂
June 16, 1926	L	June 28	June 30	July 10	♂
" 16, "	L	" 28	" 30	" 12	♀
" 6, 1927	L	" 11	" 14	" 1	♀
" 30, "	L	" 11	" 13	June 23	♂
July 26, "	L	Died May 31, 1929.			
Aug. 22, "	L	May 23	May 29	June 12	♂
Sept. 17, "	L	" 17	" 18	" 2	♀
" 17, "	L	April 8	April 11	April 22	♀
Oct. 6, 1926	L	Mar. 12	Mar. 17	Mar. 27	♀
Nov. 3, "	L			May 8	♀

Chrysops wiedemanni Kröber.

(Figure 10.)

Mature Larva.—Length, (living), 10–12 mm., (preserved), 13–15 mm. Width, 2 mm. A pale yellowish white larva; annuli pale brown, indistinct, the pubescence of the anal segment darker brown; head pale, part of the pharyngeal capsule brown. Anterior half of prothorax with pale pubescence; striæ very fine; anterior pale annuli of the meso- and metathorax rather narrow dorsally, wider laterally. Abdomen: striæ increasingly coarse from anterior to posterior; the annuli very

sparcely pubescent; lateral and ventral prolegs moderately projecting, clothed with pale setæ; anal segment rather short, sub-conical; dorsum with a row of four pubescent spots along the anterior margin, the median pair sometimes fused; the posterior pubescent ring covers about one-half the segment mid-dorsally and becomes longer to cover the anus ventrally; a pair of small, anterior, dorso-lateral projections from it often darker in color; a pair of lateral and ventro-lateral lobes also present in many specimens; a distinct pair of dorso-lateral spots anterior and lateral to the dorso-lateral projections from the posterior ring; ventrally the posterior ring is pale except in the vicinity of the anus;



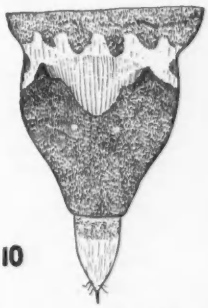


Fig. 9. *Chrysops celer* O.-S. Dorsal view of anal segment and siphon of larva. Magnified 21 diameters.

Fig. 10. *Chrysops wiedemanni* Krob. Dorsal view of anal segment and of siphon of larva. Maginfied 15 diameters.

often a pair of minute, clear, dorso-lateral spots in the posterior ring. Siphon rather short, finely striated, pubescent at the base, with a short, sharp, exsertile spine and often a few hairs at the tip. Graber's organ usually with four bodies.

Pupa.—Length, 11–12 mm. The four frontal carinæ very prominent, somewhat rounded. Pre-anal fringe with 12–15 spines in the male, 3–5 on each side in the female. Prongs of the aster prominent.

Range.—Ontario, Quebec, Kansas, Ohio, North Carolina, Louisiana, Georgia.

This is a common species throughout the State from late June to late August. Ithaca—June 26th to August 15th. It seems partial to woodland and readily attacks man and animals

in wooded regions. Hine (1903a) collected the males by sweeping along the margins of artificial lakes.

About sixty larvæ and pupæ were collected in ten different places in central New York and Northwestern Connecticut. They were found both in the muddy banks of streams and at the margins of small ponds, but always in very wet places. The majority of them were found in May and June, but they were also collected on into September.

One pupa was collected on June 19th in association with a number of larvæ of the same species, in very wet mud, among cat-tails at the margin of a small pond. Four more pupæ were collected on June 29th in a boggy meadow. Pupation in the laboratory occurred from April 8th to July 24th, the majority in late June and early July. The pupal period in the laboratory averaged 13 days. The following table gives the life history data on those larvæ in which the pre-pupal stage was recorded and of the five pupæ collected in the field.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L	June 8	June 12	June 26	♂
" 13, "	L	May 31	" 1	" 15	♂
" 13, "	L	June 11	" 13	" 26	♀
" 13, "	L	May 31	" 1	" 14	♂
" 13, "	L	June 11	" 13	" 26	♂
" 27, "	L	" 14	" 15	" 26	♂
" 27, "	L	" 11	" 13	" 26	♂
" 27, "	L	" 13	" 15	" 26	♀
" 27, "	L	" 13	" 15	" 26	♂
" 27, "	L	" 13	" 14	" 26	♂
June 5, 1927	L	" 17	" 20	July 1	♀
" 30, "	L	July 8	July 11	" 16	♂
" 19, 1928	P		June 19	June 30	♂
" 29, "	P		" 29	July 7	♂
" 29, "	P		" 29	" 2	♀
" 29, "	P		" 29	" 1	♂
" 29, "	P		" 29	" 4	♂
Sept. 3, 1927	L	May 20	May 21	June 7	♀

Goniops Aldrich.

Goniops chrysocoma Osten-Sacken.

Larva.—The larva of this species has been described in such detail by McAtee (1911), both in the first instar and when mature, that it will not be necessary for the writer to redescribe it here.

Pupa.—This is also described in great detail by McAtee, in the same paper.

Range.—New York, Ohio, Florida.

This species is infrequently collected in July and August throughout the southern half of the State, its actual abundance being difficult to determine because of its retiring habits. It has never been known to feed on blood. Ithaca—August 8th to 15th.

A female was discovered with her egg mass on August 9, 1926 in a small clump of *Fagus* at the edge of the woods. The ground was quite dry then. The attention of the writer was drawn to the fly by the rattle of her wings and she was collected before the egg mass was seen.

The egg mass, which was on the underside of a leaf about a foot from the ground, was taken to the laboratory. The mass was composed of three layers of creamy white eggs about 7 by 8 mm. in diameter and 4 mm. high. On August 19th at one o'clock, the larvæ began to emerge. It took about three minutes for an individual larva to free itself from the egg.

The larvæ were put in vials with soil from the place the eggs were collected and fed with small insect larvæ and bits of worm, but gradually they died off. Cast skins were found and several reached a length, (preserved), of 3 mm., but by February 17th all of them had died. They were always extremely sluggish.

On November 22, 1927, Dr. R. D. Harwood collected and preserved two larvæ, 5 and 15 mm. in length, of this species. They were found in leaf mold on the side of a steep, wooded hill.

For a further discussion of the biology of this peculiar fly, one should consult the papers of Walton (1908) and McAtee (1911).

Tabanus Linné.

During the course of this study, *Tabanus atratus* was reared from the egg to the adult and *bicolor*, *minusculus*, *nivosus*, *reinwardtii* and *trepidus* from larva to adult.

Key to Mature Larvæ.

This key includes those species reared by the writer and some other New York State species described by Hart (1895), Hine (1906), and Cameron (1926). Like the key to the *Chrysops* larvæ, it must be used with caution.

1. Anterior ring of prothorax widened laterally, covering more than half the lateral areas. (Fig. 12) ..... 2.
   Anterior ring of prothorax not distinctly widened laterally. (Fig. 11) .... 5.
2. Abdominal segments 1–7 with a dorsal median pubescent projection posteriorly from the anterior ring ..... 3.
   Abdominal segments without a dorsal median pubescent projection from the anterior annulus ..... 4.
3. Pubescent areas dark brown; no terminal exsertile spine; dorso-lateral projections of mesothorax swollen posteriorly ..... *atratus*.
   Pubescent areas paler; usually a terminal exsertile spine showing; dorso-lateral projections of mesothorax not swollen posteriorly ..... *stygius*.
4. Anterior abdominal annuli broad, a transverse non-pubescent area dorsally in each one; a distinct posterior annulus on most of the abdominal segments, especially the seventh ..... *reinwardtii*.
   Anterior abdominal annuli narrow, with no transverse non-pubescent area dorsally in each one; posterior annuli of abdominal segments very narrow and irregular ..... *vivax*.
5. Posterior ring of anal segment absent or vestigial ..... 6.
   Posterior ring of anal segment narrow but distinct ..... 8.
6. A lateral pubescent spot above the anus; annuli of meso- and metathorax and abdominal segments scarcely visible ..... *nivosus*.
   No lateral pubescent spot above the anus; annuli of abdominal segments slender but quite distinct ..... 7.
7. Mature larva 17–19 mm. in length alive, 20–22 mm. preserved .... *minusculus*.
   Mature larva 22–25 mm. in length alive, 26–28 mm. preserved ..... *trepidus*.
8. Elongate dorso-lateral, posterior, pubescent projections from the anterior ring of the mesothorax ..... *lineola*.
   No elongate dorso-lateral posterior, pubescent projections from the anterior ring of the mesothorax ..... 9.
9. Anal segment with a distinct anterior ring of pubescence including the anus with two posterior lateral projections from it ..... *costalis*.
   Anal segment without a distinct anterior ring ..... 10.
10. Anal segment with slender, longitudinal pubescent spots dorsally and laterally ..... *bicolor*.
    Anal segment without dorso-lateral spots, sometimes with a small, round, lateral spot ..... *septentrionalis*.

Tabanus atratus Fabricius.

Larva.—Newly hatched. Length, (alive), 2.5 mm.; (preserved), 3–3.5 mm. General color white; annuli pale brown; head light brown, the pharyngeal capsule dark. Prothorax with pale brown dorso-lateral pubescent projections from the anterior ring. Thorax and abdomen with tufts of bristles between the annuli and long setæ on the

prolegs. Anus dark with faint brown pubescence on each side. Graber's organ with one pair of bodies.

Mature. Length, (alive), 40–50 mm.; (preserved), 50–60 mm. Body hyaline with dark brown pubescent markings; mandibles and pharyngeal capsule black. Prothorax with an anterior, reddish brown annulus; from this runs a dorso-lateral longitudinal line about three-fourths the length of the segment and swollen behind; lateral areas pubescent over the anterior two-thirds or more of the segment; a ventro-median pubescent line from the posterior ring as long as the lateral pubescence; mesothorax with dorso-lateral, two lateral, and a ventro-lateral pair of projections back from the anterior ring, fused at the base laterally and not quite reaching the posterior margin of the segment; metathorax with same longitudinal lines as in the thorax, but longer and more slender, and a narrow posterior ring more or less joins them. Abdominal segments 1–7 with dorsal median projections from the anterior annulus; on the median segments, they nearly extend the full length and are often expanded posteriorly; dorso-lateral lines on abdominal segments 1–7, often broken on the median segments; indications of lateral and ventro-lateral lines, especially on the seventh segment. Dorsal prolegs short and rounded, lateral, ventro-lateral and ventral pairs more prominent, although not elongate, and provided with pale setæ. Striæ sparse dorsally and ventrally, very fine and close together laterally. Anal segment with a narrow anterior ring and a pair of small dorso-lateral spots joined to it; posterior to these, a pair of dorso-lateral spots formed by the fusion of two rather longitudinal spots; posterior ring rather narrow, joined to the anal pubescence by lateral bands of pubescence. Nearly all the longitudinal lines of the body are bisected longitudinally by a line of small non-pubescent spots. Siphon short and finely striated without a spine. Tracheal trunks large, white to the middle of the 7th abdominal segment, black dorsally posterior to that; they unite in a vertical spiracular slit.

This larva has been described previously by Walsh (1863), Riley (1870), Hart (1895) and Hine (1906).

Male Pupa.—Length, 30–35 mm.; width, 7–8 mm. Median frontal carinæ prominent, overhanging the median cleft; lateral frontal carinæ broad and less prominent; antennæ and tubercles darker than the rest of the body. Fringes of spines on abdominal segments consisting of a row of short spines and just posterior to them a row of long spines, both longer on the posterior segments; long spines of dorsum of 7th abdominal segment consisting of one to each side of the mid-dorsal line and two or three at the sides. Terminal segment: dorso-lateral comb consisting of 7–9 spines of varying lengths; lateral comb consisting of 5 or 6 very short spines; pre-anal fringe consisting of 18–22 long spines and several short ones; anus surrounded by prominent swellings; aster with a broad median part and rather short, sharp prongs, the dorsal and lateral pairs close together and separated from the ventral pair.

Hart (1895) and Hine (1906) describe the pupa.

Range.—Nebraska, Quebec, Mexico, Texas, Florida.

This species is collected throughout the State and according to Leonard, (1926), it is abundant, but it can hardly be called so in this region. The writer saw two in the three summers of work, both on cows. They are vicious blood-suckers of cattle and horses, but are never abundant enough to constitute a serious pest. Ithaca—June 28th to August 21st.

The eggs are placed on grasses, sedges and other plants in marshy ground or along streams. The mass is large, very convex, and composed of several layers. When first laid, it is pure white and later turns brownish.

An egg mass was collected by the writer on July 13th on a *Typha* leaf at the margin of a slow-running stream. The mass was made up of five layers of eggs, the whole mass coming to a point somewhat above the center. It measured 12 mm. long, 6 mm. wide, and 6 mm. high, and was slightly wider than the leaf at the point of attachment. The eggs pointed up the stem at an angle of 45°.

The eggs hatched on July 18th, at least 250 larvæ emerging. Those were put in vials with sand and algæ. They molted immediately after emerging and a number of cast skins were found. They were fed on insect larvæ, earth worms and meat, mosquito larvæ proving very satisfactory for the young larvæ. As several were put in each vial, many cases of cannibalism were observed. A great variation in rate of growth was observed. Ten days after hatching, some were twice the size of others. On October 26th, the remaining larvæ ranged in size from 14 to 28 mm. On June 29th, the one remaining larva pupated and a male emerged July 10th.

Two larvæ were collected in the field; one near the outlet of Big Lake, near Tully, N. Y. on June 12th, and the other, close to where the egg mass was found, on August 7th. The pupal stage is close to two weeks in length.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
July 13, 1926	E. (Hatched July 18)		June 29	July 10	♂
June 12, 1928	L.	July 23	July 24	Aug. 7	♂

Tabanus bicolor Macquart.

Mature Larva.—Length, (alive), 17–18 mm.; (preserved), 20–22 mm. Yellowish brown to nearly white in color; mandibles black, head reddish brown, pharyngeal capsule dark brown; annuli very pale and indistinct. Prothorax with a very slender, anterior pubescent annulus not widened

laterally, but with very narrow dorso-lateral and median ventral, posterior projections. Thoracic segments dorsally and ventrally non-striated, laterally striated. Abdominal segments uniformly quite strongly striated, the anal segment dorsally, especially so. Ventral and lateral prolegs short, rounded, with fine pale setæ; the dorsal pair flat and fused without setæ. Anal segment with a narrow posterior ring of dark brown pubescence, one or two pairs of very small, pale, dorso-lateral spots, anus surrounded by pale pubescence extending somewhat laterally of the anus. Siphon short, rounded, finely striated. Tracheal trunks large, white, darker in the anal segment and siphon; spiracular cleft yellowish brown. Graber's organ usually with 6–8 pairs of bodies.

Pupa.—Length, 15–16 mm. Frontal carinæ moderately prominent, the lateral pair scarcely separated from them. Anterior setiferous tubercles rather broad, projecting little above the surface of the head. Abdominal segments with the usual rows of spines. The area between the fringes of spines and the inter-segmental line posterior to it, very finely reticulated. Pre-anal fringe in female consisting of about five, short, stout spines on each side; in male about 20–24, long and slender in the middle, short and very stout laterally. No dorso-lateral or lateral combs. Aster broad, the lateral prongs heavy, the dorsal prongs widely separated and close to the base of the lateral prongs, smaller, and curving laterally at the tip; ventral pair very short.

Range.—Canada, Illinois, New York, Maryland.

This rather uncommon species is found throughout the southern part of the State from late June to late August. The writer failed to collect any adults during the course of this work. Hine, (1903), did not observe it annoying stock. Ithaca—June 30th to August 11th.

Four larvæ were collected. One was found in the muddy bank of a stream near Ithaca on June 17th, 1926. The other three were collected in mud at the margin of a small pond in an open pasture lot about twelve miles from Ithaca, on June 17th, 1928. The pupal period in the laboratory was about ten days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 17, 1926	L	July 13		July 25	♀
" 17, 1928	L		July 16	" 26	♂

Tabanus minusculus Hine.

Mature Larva.—Length, (alive), 18 mm. Body translucent, bright green; annuli quite distinct; the narrow posterior ring of the prothorax not widened laterally. Prolegs short with fine setæ. Anal segment non-pubescent except for the anus and a narrow ring around it. Siphon short, finely striated. Spiracular cleft pale brown.

Female Pupa.—Length, 15 mm. Frontal setiferous tubercles nearly absent, the setæ coming directly from the surface of the head; the frontal carinæ scarcely visible, the front of the head rounded. Dorso-lateral comb of terminal segment consisting of about seven rather short spines; lateral and pre-anal combs close together, each consisting of six or seven short spines. Aster with dorsal and ventral prongs very small, the lateral prongs large.

Range.—Canada, Maine, Massachusetts, New York.

This species appears to be quite uncommon in the State. No adults were collected by the writer.

On May 24, 1928, Dr. Paul R. Needham gave the writer a larva which he had collected in sphagnum moss at the McLean Bogs. On June 27th, it had pupated, and on July 3rd, an adult female emerged. It was sent to Dr. Hine and determined by him.

Tabanus nivosus Osten-Sacken.

(Figure 11.)

Mature Larva.—Length, (living), 25–28 mm., (preserved), 30–34 mm. General color pale yellow; head capsule reddish brown, mandibles brownish black; annuli very indistinct, there being only very sparse pubescence in the vicinity of the prolegs. Ventral thoracic bristles black, usually double. Prothorax with a narrow, yellowish anterior ring, slightly widened laterally. Dorsal and ventral areas of all the segments except the anal, non-striated; lateral areas very finely striated except on the prothorax, where the striæ are quite coarse. Prolegs short, with fine yellowish setæ. Anal segment coarsely striated on the wide, anterior part, quite finely on the narrower posterior part, there being an increase in the number of striæ here and not solely a convergence of those on the anterior part. Anus finely pubescent, the anterior and posterior crescentic protuberances surrounding it covered with coarse, brownish black setæ; laterally, just above the anus, a patch of rather coarse, yellowish brown pubescence. Siphon of moderate size, finely striated, and often provided with a few yellowish hairs at the tip.

Pupa.—Length, 19–21 mm. Frontal tubercles moderately prominent, rugose, slightly oblique. Dorso-lateral and lateral combs of the terminal segment present, the former with longer and slenderer spines than the latter; pre-anal fringe in female consisting of 8–10 slender spines on each side; in male of 25–30 all together. Aster with long lateral prongs, the dorsal and ventral pairs short.

The larva and pupa of this species has previously been described in detail by Cameron (1926).

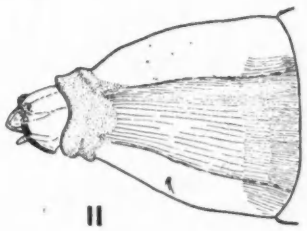
Range.—Saskatchewan, New York, Ohio, New Jersey.

This species is moderately abundant in the State in June and July. The writer collected one adult, the only one recorded

from Ithaca, on June 29th. Hine (1903a) in Ohio, and Cameron (1926) in Saskatchewan, found it attacking man and horses readily, the former finding it an annoying pest at the bathing beach.

Seven larvæ were collected in the muddy banks of small streams. The pupal period was about 15 days, in the laboratory. The following table gives the data on those reared.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L		June 3	June 19	♂
Sept. 6, 1927	L		" 1	" 15	♀
" 6, "	L		" 16	" 30	♀
" 8, "	L		" 12	" 28	♂



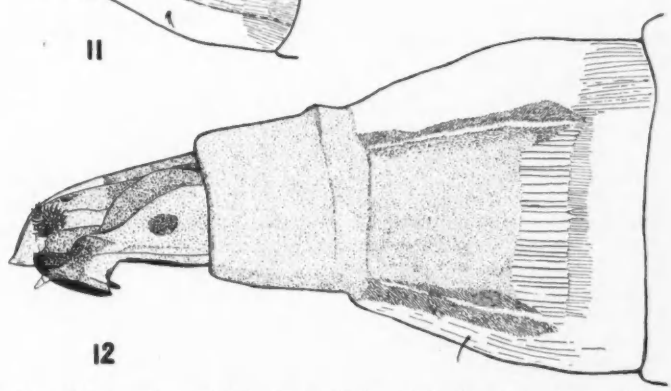


Fig. 11. *Tabanus nivosus* O.-S. Lateral view of head and prothorax of larva. Magnified 13.5 diameters.

Fig. 12. *Tabanus reinwardtii* Wied. Lateral view of head and prothorax of larva. Magnified 24 diameters.

Tabanus reinwardtii Wiedemann.

(Figure 12.)

Mature Larva.—Length, (alive), 27–30 mm., (preserved), 36–40 mm. Width, 4 mm. General color white; head capsule reddish brown, the mandibles black; the dorso-lateral hair tufts reddish; annuli usually grayish brown, sometimes yellowish. Dorsal and ventral areas of prothorax with almost no striæ; lateral areas finely striated. Prothorax

with a narrow anterior pubescent ring with a pair of dorso-lateral and a pair of ventro-lateral posterior projections; the area between these pubescent; a mid-ventral line as long as the others, none of them reaching the posterior margin of the segment; meso- and metathorax with a narrow anterior ring, wider laterally with a dorso-lateral, two lateral, and a ventro-lateral, slender, posterior projection on each side. Ventral thoracic bristles brownish. Abdominal segments 1–7 with annuli growing broader posteriorly, with a dorsal, transverse, non-pubescent area; these segments also with a posterior ring, widest on the seventh segment; abdomen with lateral areas more finely striated than the dorsal or ventral; prolegs quite short, tipped with fine yellowish or brownish setæ. Anal segment with a series of four dorso-lateral spots often more or less fused; when separate, they consist of an anterior, rather median pair, a slightly more lateral and posterior pair, and two more, one behind the other, posterior to these; usually the latter three pairs are fused on each side giving an L-shaped mark with the short arm anterior and pointing laterally; from the rather narrow, but definite posterior ring a pair of pubescent lines run forward and then down, on each side, to join the pubescence of the posterior anal protuberance; anterior anal protuberance also distinctly pubescent. Anus quite prominent. Siphon about the length of the posterior ring, conical, finely striated, with a prominent, vertical spiracular slit. Graber's organ usually showing one or two pairs of bodies in the sac and one to three bodies, in tandem, in the tube.

Pupa.—Length, 23–25 mm. Yellowish or reddish brown in color. Median frontal carinæ prominent, separated by a narrow cleft; lateral carinæ smaller, closely joined to the median pair; area around carinæ very rugose; frontal setiferous tubercles prominent. Abdominal spiracles quite prominent. Dorso-lateral comb of the terminal segment consisting of four or five spines; region of lateral comb indicated by a rugose swelling; pre-anal fringe in female consisting of four or five spines on each side. Aster broad, the prongs of moderate size, sharply pointed and slightly recurved at the tips; the dorsal pair extends nearly straight up and is about equal in size to the lateral pair; in the female, the ventral prongs are somewhat smaller than the others; in the male, the three pairs are nearly equal in size.

The larva and pupa of this species has been previously described in detail by Cameron, (1926).

Range.—Canada, Colorado, New York, Illinois, Maryland.

This species is rather infrequently encountered throughout the State during the mid-summer. Although this was the most frequently collected *Tabanus* in the larval state, only one adult, and that a battered male, was collected during the course of this study. Cameron (1926) and Philip (1928) also found this disparity between the number of larvæ and adults encountered. Cameron never found it attacking horses or cattle. Ithaca—June 25th–August 6th.

Cameron (1926) describes an egg mass laid by a reared female.

Eighty or more half grown to fully grown larvæ were collected in every month from April to December with the exception of October. Over half of these were collected in July. They were found in rather heavy mud close to the waters edge of a sluggish backwater fed by springs, of a rapid stream, and in a cat-tail bog. One was collected at the edge of a stream in a dense mass of willow rootlets. The larvæ ate earthworms with great avidity and often attacked the worm the instant it was put in the jelly glass. Several times I have seen a larva seize a worm, hang on in spite of its struggles, and in a very short time cut the worm in two.

Pupation occurred in the laboratory from May 24th to July 15th. The pupal period was about 17 days. The following table gives the life history data of those successfully reared.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 14, 1927	L			May 2	♂
May 12; "	L		June 14	July 1	♀
" 12, "	L	June 14	" 16	" 1	♂
June 18, "	L		" 26	" 1	♀
Nov. 24, 1926	L	May 19	May 22	June 11	♂
" 24, "	L			" 1	♂
Dec. 1, "	L	May 30	June 1	June 17	♀

Tabanus trepidus McDunnough.

Mature Larva.—Length, (living), 22–26 mm. General color bright, translucent green; annuli brownish; head brownish, the pharyngeal capsule black. Prothorax with a narrow anterior ring not widened laterally; finely striated laterally and ventrally; meso- and metathorax with a pubescent anterior ring and slender posterior projections at the dorso-lateral line. Abdomen finely striated throughout; anal segment with a narrow, dark posterior ring and a narrow ring of pubescence around the anus; otherwise non-pubescent. Siphon short, rounded, finely striated. Tracheal trunks brown through anal segment and siphon. Spiracular cleft dark brown.

Pupa.—Length, 19–21 mm. Frontal carinæ absent, the area between the antennæ gently rounded with just a trace of a median groove. Frontal setiferous tubercles absent, the setæ coming directly from the surface of the head; antennæ very flat, broad at the base, forming an equilateral triangle. Dorso-lateral comb of terminal segment of 4–5 spines in the male, 2–3 in the female; lateral comb present in both sexes with 5–10 spines, usually more in the male; pre-anal fringe in male consisting of a row of long spines running from one lateral comb to the other. In the female, 7–10 on each side; aster with sharply

pointed prongs, slightly recurved at the tip; dorsal pair short, pointing straight up; lateral pair very large, pointing up and back; ventral pair very short, pointing slightly up.

Range.—British Columbia, Ontario, Nova Scotia, New York.

This species is infrequently encountered in the cooler portions of the State in mid-summer. No adults were collected by the writer nor have any been recorded from Ithaca.

Five larvæ were collected in sphagnum moss in a small upland bog. They were extremely active and viciously attacked the writer, puncturing the skin and causing a sharp, stinging pain. They readily fed on earthworms.

Pupation occurred in early July, the pupal period lasting 12 to 13 days. The following table gives the data on the four successfully reared. The fifth pupated but failed to emerge. The specimens were determined by Dr. Hine.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 21, 1927	L		June 9	June 21	♂
" 21, "	L		" 9	" 21	♂
" 21, "	L	June 9	" 10	" 23	♀
" 21, "	L			July 6	♀

Conclusions.

A great deal remains to be learned in regard to the bionomics of the Tabanidæ. Relatively few species have been studied with any degree of thoroughness and it is particularly important that the early stages should be sought elsewhere than in the vicinity of water. The way in which the larvæ pass the winter, their food, their length of life and the number of molts all require further study.

The larvæ present a number of characters of value for determination of the species, and as new larvæ are described, the preceding imperfect key can be enlarged and improved.

Finally, the writer wishes to acknowledge his particular indebtedness to Dr. Robert Matheson who suggested this problem and under whose kind and able direction it was carried out. To Dr. James S. Hine many thanks are due for the identification of several species and for many helpful suggestions. Also, the writer is grateful to Mr. Albert W. Force for the two drawings of posterior spiracles (Figures 3 and 4). To the many others who have shown an interest in the work and who have donated specimens, the author expresses his sincere gratitude.

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THE GENITALIA AND WING VENATION OF THE CUCUJIDÆ AND RELATED FAMILIES*

J. W. Wilson.

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INTRODUCTION.

The family Cucujidæ has attracted considerable interest because of the remarkable structural differences found in some of the genera. This diversity of structure indicates that the family is a very old one which has lost many of the intermediate forms. Sharp and Muir ('12) found that the male genitalia of the Cucujidæ are also very variable and for this reason they give the family a central position in the series Cucujoidea. A number of families are then derived from the Cucujidæ, including the Coccinellidæ and Endomychidæ. In some cases the connecting links between the families are rather obscure. A study of the morphology of the Coccinellidæ begun at North Carolina State College convinced me that a further study of the genitalia of the Cucujidæ and the related families would probably clarify the relationship of these families.

The venation of the wings of the Coleoptera was used successfully by Lameere (1900) and Ganglbauer (1903) in determining the phylogenetic position of the larger groups of the Coleoptera, but I have been unable to find any reference to a detailed study of the wings of the Cucujoidea. I have included a description of the wings of these families in order to compare the results from the study of the two organs.

*Contribution from the Entomological Laboratory, Bussey Institution, Harvard University, No. 318.

SECTION I

Comparative Study of the Genitalia of the Cucujidæ and Related Families.

REVIEW OF PREVIOUS WORK.

The first work on the subject of the genitalia of the Coleoptera was carried on by Verhoeff (1893) who studied the terminal abdominal segments, as well as the male and female genitalia of seventeen families. After a very detailed discussion of these parts Verhoeff concludes that the Coccinellidæ are sufficiently distinct from the other Coleoptera to justify separating them as a suborder, Siphonophora, from the remainder of the Coleoptera which are included in the suborder, Asiphona. This view was very strongly attacked by Weise (1895) and Schwartz (1895). Verhoeff's conclusions have received little attention in Europe, but Leng (1920) in his introduction to the "Catalogue of the Coleoptera of North America" states that he gives the Coccinellidæ an isolated position with the hope that Verhoeff is partly correct.

The first general survey of the male genital tube in the Coleoptera was published in 1912 by Sharp and Muir. These authors divided the Coleoptera into the eight series Byrrhoidea, Caraboidea, Cucujoidea, Staphylinoidea, Malacodermoidea, Tenebrionoidea, Scarabaeoidea, and Phytophagoidea. The more primitive type of aedeagus is found in the series Byrrhoidea, while two types of genitalia are found in the family Colydiidæ. One type is characteristic of the Byrrhoidea, and the second characteristic of the Cucujoidea. The Cucujoidea is admittedly a series of heterogeneous nature subject to division. It is noteworthy that many of the families of the old series Heteromera are placed in the Cucujoidea, leaving the Cistelidæ, Lagriidæ, Monommidæ and Tenebrionidæ as a homogeneous series called Tenebrionoidea.

The series Caraboidea (Adephaga of other authors) is recognized as the most distinct and homogeneous series of the Coleoptera. The Cupedidæ are shown to be distinct from the Caraboidea, and are placed in the series Byrrhoidea. The six series Caraboidea, Staphylinoidea, Malacodermoidea, Tenebrionoidea, Scarabaeoidea, and Phytaphagoidea each have characters in common but each also shows a definite direction of progressive modification.

Tanner (1927) made a study of the female genital tube and arranged the families much as Long has arranged them in his catalogue of the Coleoptera.

In preparing the material for this paper I made an effort to obtain female as well as male specimens. After comparing the structure of

the females, however, I decided not to include them for the structure of the female tube differs very little among the genera of the Cucujidæ, or between the Cucujidæ and such families as Mycetophagidæ and Erotylidæ. The fact that the Endomychidæ and Coccinellidæ both showed a great shortening of the membranous ninth segment should be noted however.

Since frequent reference is subsequently made to Boving's division of the Cucujidæ on larval structures I thought it advisable to include a résumé of his results here.

Böving's (1921) studies resulted in a division of the Cucujidæ into four families. The family Silvanidæ includes the following genera: Telephanus, Nausibius, Coccidotropus, Eunausibius, Oryzaephispus, Cathartus and Silvanus, which are distinguished from the Cucujidæ by "absence of cerci. The eighth abdominal segment is normally developed; ninth, small, ventrally rudimentary; tenth, long, extending far behind the ninth segment; six ocelli." The family Cucujidæ possesses cerci, and is divided into two subfamilies Hyliotinæ and Cucujinæ. The Hyliotinæ includes the genera Brontes and Dendrophagus, while Psammoecus, Pediacius, Platisus and Cucujus constitute the subfamily Cucujinæ. A third family Laemophloeidæ is distinguished by "Maxillary mala (possibly galea) obtuse, with or without well defined uncus, which when present is laterally placed on inside of mala." The genera Prostomis and Dryocora (an Australian genus) are placed together in the subfamily Prostominæ. And Prostominia, Narthecius, Lathropus, Laemophloeus, Dysmerus, Hemipeplus, and Inopeplus form a second subfamily Laemophloeinæ. The genera Catogenus and Scalidia differ from the other genera to such an extent that Böving gives them the family name Scalidiidæ and places them with the larvæ of the Cleroidea series.

GENERAL MORPHOLOGY OF THE AEDEAGUS.

When the abdomen of a generalized Coleopteron is examined, nine or ten tergites and nine sternites may be easily distinguished. There are ten distinct tergites in *Hippodamia convergens* and *Enarsus bakewelli*. In the case of the latter species Sharp and Muir found ten sternites present. The anus opens on a small membrane between the tenth tergite and sternite so that the digestive tract is completely separated from the genital tube in *Enarsus bakewelli*. In the case of *Hippodamia convergens* and other members of the order the tenth sternite is reduced to such an extent that the anus is separated from the genital tube by a very short membrane which is continuous with the second connecting membrane (Fig. 52 CM2), connecting the aedeagus with the abdomen. The ninth sternite is a short segment bearing a spicule at the

anterior border. The attachment and shape of this spicule varies a great deal in different families. Sometimes it appears to be a direct continuation of the ninth sternite, and in these cases it is usually a long slender chitinous process. In other cases it is located in the membrane between the ninth sternite and the second connecting membrane.

In discussions of the abdomen and genitalia of the insects both morphologists and systematists have arrived at varying conclusions concerning the number of abdominal segments. Systematists usually limit themselves to numbering the segments which are clearly visible. Disagreement on this point has arisen among the morphologists for various reasons, which are summarized by Newell (1918) as follows: "(1) Because of the loss of certain sclerites. (2) Because of differences in the point of view: viz. some investigators begin to count at the cephalic, while others begin at the caudal end of the abdomen, and still others do not correlate closely dorsal and ventral sclerites. (3) Because, undoubtedly, of failure to observe the sclerites present in the caudal region, due in many cases to the lack of potash or other suitable reagents and methods for exposing chitinized parts."

In the coleoptera the first two sternites have usually fused completely with the third sternite, but in many cases vestiges of the first two sternites may be observed at the anterior border of the third sternite, and folded under the posterior coxæ. One or two caudal segments are also usually withdrawn into the abdomen. Thus it is seen that the number of segments given for the Coleoptera by various investigators varies from eight to eleven. Peytoureau (1895) finds eight in Hydrophilus and nine in Dytiscus, Kolbe (1893) counts nine in the Lamellicornia, Verhoeff (1893-96) numbers ten in the families he studied, while Berlese (1903) concludes that eleven abdominal segments is the typical number for the Coleoptera in general. Muir (1915) states that nine segments are usually present though he found ten complete segments in *Enarsus bakewelli*. Newell (1918) emphatically states that eleven segments are present in Harpalus, and Cybister females with ten segments in the males of these two genera and in both sexes of Hydrophilus and Doryphoria. *Doryphoria decemlineata* lacks the tenth sternite, however. In the Coccinellidæ and *Endomychus biguttatus* I have been able to count only ten tergites and nine sternites while in the Mycetophagidæ, Cucujidæ, Nitidulidæ, Monotomidæ, Phalacridæ, Erotylidæ, and Cryptophagidæ nine complete segments are present.

Eight tergites and six sternites are visible in the Coccinellidæ and Endomychidæ, the sixth visible sternite being in reality the eighth

sternite. The membrane connecting the ninth segment with the eighth is long, allowing the ninth and tenth segments to be withdrawn into the abdomen. As is illustrated in figures 37 to 53 tergite ten is closely attached to the irregularly shaped ninth tergite. The digestive tube opens at the posterior border of the tergite and is attached below to the second connecting membrane of the genital tube. The tenth sternite is absent and the second connecting membrane attaches to the posterior border of the ninth sternite.

In the remainder of the families studied, the eighth sternite is withdrawn into the abdomen and in the case of the Cucujidæ and Nitidulidæ the eighth tergite is also concealed under the seventh tergite. The digestive tract then opens at the posterior border of the ninth tergite and the genital tube at the posterior border of the ninth sternite.

The genitalia of insects are borne at the caudal end of the abdomen and the parts of the genitalia have been termed gonapophyses by Huxley. It would seem natural to homologize these appendages with the anlagen of the legs found on the terminal somites of the embryonic germ band, but there are two opposing views on this subject.

The following investigators have considered the genitalia or gonapophyses as developing from the abdominal anlagen of the legs: Weismann in 1866; Krapelin in 1872; Kowalewsky in 1872; Dewitz in 1875; Huxley in 1877; Chlodkowsky in 1891; and Wheeler in 1893. These authors differ, however, in the details of their explanation.

Wheeler (1893) traced these anlagen to the time of hatching in Xiphidium and pointed out that Dewitz in 1875 had traced the development of the ovipositor in *Locusts viridissima* to the adult so that we have a complete history of the anlagen to the adult. Wheeler concluded that part of his discussion as follows: "While there can be no doubt about the appendages of the eighth and ninth segments which go to form the two outer sheaths of the ovipositor or sting the development of the innermost pair of blades is by no means so satisfactory. But whether this pair is only a portion of the ninth pair of appendages, as most authors claim, or represents the tenth pair of appendages, as I maintain, the main question at issue is in no wise affected; for it still remains true that the ovipositor consists of two or three pairs of modified ambulatory limbs." In the male Xiphidium Wheeler has shown that the appendages on the ninth segment persist to form the definitive style, while the appendages of the eighth and tenth segments disappear very early. Cholodkowsky (1891) had previously made similar observations on Blatta. The style, therefore, must be considered homologous of the second pair of appendages.

On the other hand, a number of authors are of the opinion that the gonapophyses are not homologous with the ambulatory appendages. Heymons is one of the stronger opponents of the view held by Wheeler and others. After a study of a large number of species of Locustidæ, Gryllidæ, and Hemiptera, Heymons published a résumé of his work in 1899 in which he concludes that it is a fundamental principle in insect embryology that there is no relationship between the anlagen of the ambulatory appendages and the gonapophyses.

Heymons maintains that the genitalia in Xiphidium and other Locustidæ begin developing at a very early period, even before the atrophy of the anlagen of the segmental appendages. Heymons also claims that the very small size of the sternites in Locustidæ would lead to a confusion of the embryonic limb-rudiments with the developing gonapophyses. While in other forms where the sternites are larger, such as *Lepisma saccharina* and certain Hemiptera, Heymons asserts that the gonapophyses do not develop in the same region of the sternites where the anlagen of segmental appendages occur.

In spite of Heymons' objections the majority of embryologists and morphologists believe the genitalia to be derived from the anlagen of the segmental appendages. In the Hymenoptera, Lepidoptera, and Diptera the anlagen on the eighth, ninth and tenth segments disappear, as well as those on the anterior segments. This has led some authors to suppose that the anlagen remain undeveloped until some later stage in development. This view is expressed by Korschelt and Heider (1892) as follows: "We should have to suppose, as Graber also has pointed out, an embryonic rudiment remaining for a considerable time in a dormant condition. On the whole, the embryonal data seem to support the view of Balfour which Cholodkowsky adopted, and to which Graber was inclined, that the abdominal appendages of Lepidoptera and Hymenoptera are to be regarded as true limbs. We have already had several examples, in the Crustacea, of the disappearance and redevelopment of a limb and of a rudiment which has meanwhile been latent. A similar example is afforded among the insects by the thorasic limbs of many Hymenoptera. These appear as rudiments in the embyro, disappear later, and reappear in the imago."

In some Coleoptera no traces of the anlagen of the abdominal appendages is found in the developing embryo. In describing the ontogeny of Doryphora Wheeler (1889) makes the following statement in regard to the abdominal anlagen of the legs: "In none of the preceding stages have I observed what is so prominent in Blatta, viz. the appearance of appendages on the abdominal somites. There are not the slightest traces of even the pair of appendages of the first abdominal somite, which in Blatta develop into the large glandular organs of which I have treated elsewhere."

Verhoeff (1893-95) in his work on the genitalia of the Coleoptera and Hemiptera homologizes the median genital appendages with the distal segments of the legs, and the lateral gonapophyses with the coxæ of these legs, therefore, regarding the origin of two pairs of genitalia from one pair of ambulatory appendages belonging to one somite, instead of from two pairs belonging to two successive somites, or in other words, from at least four isolated evaginations having no connection with the anlagen of the segmental appendages found in the embryo.

Newell (1918) studied the morphology of four species of coleoptera with representatives of the other orders of insects. In this paper the genitalia are also homologized with the abdominal appendages of somites eight, nine and ten. The appendages are labelled I, II, and III,

and are considered to be derived from somites eight, nine and ten respectively. The sclerite labelled sternite 10 by Newell is the spiculum according to Sharp and Muir. Muir in 1915 has shown that this structure is developed during the pupal stage at the base of the second connecting membrane, and therefore can not be the tenth sternite. Newell labels the tubular portion of the aedeagus (equal to the median lobe of Sharp and Muir) as appendage III in *Harpalus calignosus* and *Doryphora decemlineata* while in *Cybister fimbriolatus* the same part is labelled appendage II, and the outer lateral lobes are labelled III. It is not clear from the figures which part is considered appendage II or III in Hydrophilus. Appendages I and II are believed to be present in all four forms studied though appendage I is rudimentary in males of Doryphora and is completely absent in *Harpalus calignosus*. These conclusions are based entirely upon comparative morphology of the imago.

Sharp and Muir (1912) give a completely different explanation of the origin of the genitalia after their study of the comparative morphology of the organ. They believed the genitalia to be developed as an invagination and chitinization of the membrane between the ninth and tenth segments and that no part of the sternites entered into the composition of the aedeagus. This explanation was more in accord with the observations on the embryology of the Coleoptera because none of the anlagen of the abdominal segments develop. Later Muir (1915 and 1918) studied the ontogeny of three species and found that the genitalia develop as they supposed from the membrane between the ninth and tenth sternites.

The forms studied by Muir were *Rhabdomerus obscura*, *Coccinella repanda*, and *Carpophilus humeralis*. In the early stages of the male pupa of these species the testes are attached, each by a fine testicular thread, to a small mass of cells between the ninth and tenth sternites. This cellular mass forms an invagination which increases in size and grows into the body cavity. At the apex of this tube where the testicular threads are attached another invagination takes place to form the ejaculatory duct. The membranous tube then evaginates and this evaginated portion forms the eurazygos, while the proximal part of the membrane becomes the second connecting membrane attaching the aedeagus to the body. The first development of the eurazygos is the formation of the tegminal fold separating the median lobe from the tegmen. The tegmen becomes thickened and chitinized. From the anterior end of the tegmen the second connecting membrane is again invaginated to form the tegminal strut while from the posterior end the lateral lobes are formed as outgrowths from the tegminal fold. While this is taking place a construction is formed about the eurazygos beyond the tegminal fold, dividing it into two parts. The basal portion lengthens and becomes chitinized, forming the median lobe. The apical portion becomes crumpled and is later withdrawn into the median lobe as the internal sac. The median strut is developed as an outgrowth from the base of the median lobe and becomes heavily chitinized.

We may now discuss the general structure of the parts of the aedeagus of the forms studied.

In all cases except that of *Carpophilus pallipenis* the median lobe is well developed, more or less tubular, with a median orifice at the distal end and a median foramen at the proximal end. In many cases there is a median strut projecting from the proximal end of the median lobe to which muscles are attached. In the *Nitidulidæ* and related families the median lobe is articulated to the tegmen on the ventral aspect and swings in and out of the tegmen.

The tegmen in the generalized forms represented by the Mycetophagidæ consists of the basal piece and lateral lobes on the ventral aspect of the aedeagus. In such forms where there is no chitinous dorsal portion the second connecting membrane and the dorsal membrane of the tegmen are indistinguishable. But in a majority of the specimens the tegmen forms a complete ring around the median lobe. The lateral lobes vary a great deal in position, being on the ventral aspect, at the sides, or on the dorsal aspect of the median lobe.

The internal sac is comparatively simple in all of the specimens studied. In the simplest form it is a straight tube and can hardly be distinguished from the ejaculatory duct. In *Glistrochilus fasciatus* the internal sac is highly specialized, having the proximal end formed like a bulb, bearing chitinized side pieces and setæ. A shot curved flagellum is attached at the apex.

The flagellum is an inconstant structure, present in some genera and absent in others.

METHOD.

All of the material used in the preparation of the genitalia were dried museum specimens, some of it being very old. In order to remove the aedeagus the specimens were placed in water and heated for ten or fifteen minutes. The elytra were then spread apart and the tegmen carefully separated from the sternum with a fine needle. In most cases it was only necessary to separate the last two or three tergites from the sternites. The genitalia and dried contents of the abdomen were then removed, and placed in a solution of caustic potash. After the muscles had been dissolved away the genitalia were mounted in balsam between small cover glasses. A hole was punched in a rectangular piece of cardboard about .5 mm. thick, and the bottom cover glass glued in place. The depression thus formed was filled with balsam, and the aedeagus arranged in the desired position. The upper cover glass was then put in place, and a label placed on the opposite end of the cardboard. After drying, a pin was run through the cardboard and the mount was ready for study. This method has the advantage of making the genitalia readily available, and it obviates the danger of loss, which is considerable when very small specimens are being studied. If it becomes necessary to change the position of the aedeagus it was easily remounted by soaking the cover glasses off in xylol.

All of the drawings were made with the camera lucida. In the case of the genitalia the line placed at the side of the drawing represents one-fourth of a millimeter, except in *Glistrochilus obtusus* and *Languria bicolor* where the line is drawn to represent one millimeter.

SPECIAL ANATOMY.

MYCETOPHAGIDÆ.

Mycetophagus flexuosus Say. Fig. 25.

Median lobe (ML), tubular with a large oval median foramen (MF) at the proximal end, produced at each side of the median foramen to form two short strut-like projections which do not extend beyond the anterior border of the basal piece (BP). Median orifice (MO) a small circular opening at the extreme end of the median lobe. Internal sac (IS) a simple, tubular structure without flagellum or other modifications sometimes found in more highly evolved aedeagi. Tegmen composed of two parts, basal piece (BP) and lateral lobes (LL). Basal piece broad, extending beyond the median lobe for a short distance, transverse, rather broad, turned up at the sides so as to form a trough in which the median lobe rests. Lateral lobes attached to the basal piece by a thin membrane which allows movement of the lateral lobes. Thus we have the name trilobe applied to this type of aedoeagus. Lateral lobes (LL) enlarged and extending around the median lobe but not fusing on the dorsal surface to form a tube.

Typhoea fumata (L.). Fig. 23.

Median lobe (ML) as in *Mycetophagus flexuosus*, with the median foramen (MF) more elongate, median orifice (MO) at the extreme distal end of the median lobe. Basal piece (BP) broad and extending further around the median lobe than in the aedoeagus described above. Internal sac (IS) simple. Lateral lobes (LL) joined to the Basal piece as in *Mycetophagus flexus*. Lateral lobes almost contiguous on the dorsal surface.

The type of aedoeagus found in the Mycetophagidæ was designated as the trilobe type because of the intimate connection of the median lobe with the tegmen to form one component and the lateral lobe at each side of the median lobe forming the other two components of the trilobe aedoeagus.

CUCUJIDÆ

The genera usually placed together in this family show a very great diversity of structure in body characters. Such differences in external structure have caused some systematists to suggest that the family be divided. Böving (1921) recently published a plan for separating the group according to larval characters in which he recognizes four families. All of the genera available for dissection were studied in order to determine whether or not this division of the family would be substantiated or refuted by the evidence from the male aedoeagus. Fifteen of the twenty-two genera were dissected and figured.

It has already been pointed out in the case of the Mycetophagidæ that the tegmen is placed on the ventral aspect of the median lobe. This condition is also found in the Cucujidæ for the lateral lobes rest upon the sternites, and are not upon the dorsal aspect of the median lobe as described by Sharp and Muir. This then obviates the necessity of explaining how the lateral lobes of the tegmen came to lie on the dorsal aspect of the median lobe if we are to derive the Cucujid aedoeagus from the trilobe type of aedoeagus. That the Cucujidæ were probably derived from the trilobe type of aedoeagus is demonstrated by Hemipeplus and Dendrophagus.

Hemipeplus marginipennis (Lec.). Fig. 16.

Aedoeagus as long as the last two segments of the abdomen, very narrow and slender when compared with the aedoeagi of other genera. Median lobe (ML) a simple straight tube attached at the proximal end to the tegmen by a short connecting membrane. Median foramen at the extreme proximal end, large, oval in shape with the sides of the median lobe slightly produced. Median orifice (MO) a small rounded opening at the extreme distal end of the median lobe. Ejaculatory duct and internal sac undifferentiated. Internal sac small without flagellum. Tegmen consisting of broad rounded lateral lobes and a long Basal piece. The tegmen does not form a complete chitinous ring around the median lobe. Basal piece (BP) slender at the proximal end and extending slightly beyond the median lobe, becoming larger toward the middle and extending up around the median lobe; divided on the ventral side and continuing to slightly beyond the median lobe as two large lateral lobes, (LL).

This aedoeagus like that of the Mycetophagidæ is distinct from the other Cucujidæ in that the tegmen does not form a complete ring around the median lobe. The median lobe itself is a simple tubular structure in the Mycetophagidæ and in Hemipeplus. On the other hand the aedoeagus differs from the Mycetophagidæ in that the lateral lobes are completely fused with the basal piece so that they seem to be continuations of the basal piece.

Inopeplus reclusa (Lec.). Fig. 32.

The aedoeagus of this form is very small and slender, measuring .5 mm. in length. Median lobe (ML) tubular, and straight with the small rounded median foramen at the extreme proximal end, and the small median orifice (MO) at the opposite end. Internal sac (IS) a simple straight tube without flagellum. Tegmen on the ventral side of the aedoeagus, not forming a ring around the median lobe; separated into two lateral lobes which extend a little beyond the end of the median

lobe. The tegmen bears at about the middle of each side a short projection which extends toward the mid-ventral line.

Inopeplus immunda Reit. Figs. 26 and 27.

Median lobe (ML) short appearing as a straight tube from a dorsal view but when observed from a lateral view it is seen to be curved at the middle and slightly expanded dorsoventrally with the median foramen in the form of a narrow slit-like structure. Median orifice (MO) a small circular opening at the distal end of the median lobe. Internal sac simple, tegmen about the same length as the median lobe, forming a groove-like receptacle for the median lobe; divided beyond the middle into two projections or lateral lobes.

The aedoeagus of both *I. reclusa* and *I. immunda* have the tegmen located on the ventral side of the median lobe with the basal piece extending about two-thirds of the length of the median lobe, and divided into two lateral lobes beyond this point. The tegmen of *Hemipeplus marginipennis* is of similar structure, but the lateral lobes more nearly enclose the median lobe than in Inopeplus. The fact that the tegmen does not completely encircle the median lobe places Inopeplus with Hemipeplus near the Mycetophagidæ.

Prostomis mandibularis Fab. Fig. 28.

Aedoeagus very small, flattened dorso-ventrally, 0.5 mm. in length which is very short in comparison with the length of the adult body. Median lobe (ML) about one-half as long as the tegmen, tubular, with the larger median foramen at the proximal end and the smaller median orifice at the opposite end; attached to the tegmen by a very short connecting membrane. Internal sac (IS) simple, without flagellum. Tegmen located ventrad of the median lobe and consisting of two parts the basal piece (BP) and lateral lobes (LL). Basal piece convex from a ventral view, distinctly separated from the lateral lobes by a more heavily chitinized area which extends along the mid line. Lateral lobes short prolonged into slender seta-like processes.

Prostomis mandibularis like Inopeplus and Hemipeplus has an aedoeagus which is small with the tegmen not completely encircling the median lobe. Because of this general similarity Prostomis is placed near Hemipeplus and Inopeplus. But when we consider the details of the parts the aedoeagi are very different. In Prostomis, the basal piece is expanded and convex, the lateral lobes are produced into small seta-like projections, and the median lobe is only about one-half as long as the tegmen. In Hemipeplus and Inopeplus the basal piece is long and slender, the lateral lobes bear no setæ of any kind, and the median lobe is almost as long as the tegmen.

Dendrophagus cygnaei Mann. Fig. 11.

Aedoeagus flattened dorso-ventrally but rather long and broad. Median lobe (ML) not completely chitinized on the dorsal surface, tapering to a point on the ventral surface. Median orifice (MO) very large, elliptical in shape. Ventral surface of the median lobe produced into a long flattened median strut (MS) which extends a short distance beyond the basal piece. Internal sac (IS) simple, without flagellum. Tegmen ventrad of the median lobe and forming a complete ring around the median lobe. Basal piece (BP) long and broad, extending well up around the sides of the median lobe, with a short connecting piece across the dorsal surface. Lateral lobes broad and flattened, extending beyond the distal end of the median lobe, and bearing numerous setæ.

The tegmen of Dendrophagus is essentially similar to the tegmen of the trilobe type in Hemipeplus, both having the broad basal piece and the flattened lateral lobes on the ventral surface. The necessary changes required for the derivation of the Cucujid aedeagus from the trilobe type are a lengthening of the first connecting membrane between the median lobe and the tegmen, and a formation of a complete ring around the median lobe. The lengthening of the first connecting membrane does not take place in Dendrophagus. The ring around the median lobe is completed by a chitinization of the tegmen to form a short band across the dorsal surface.

Brontes dubius Fabr. Fig. 8.

Aedoeagus broad and flattened dorso-ventrally. Median lobe (ML) fusiform, with both distal and proximal ends pointed. Median foramen small, V-shaped and located on the dorsal surface. Median orifice a rather large opening on the ventral surface. Internal sac (IS) about three times as long as the median lobe, with four thickened areas on the walls of the portion inside the median lobe; expanded beyond the median foramen, and with small spines turned basad in localized areas. A long branched flagellum (F) at the proximal end. Surrounding the flagellum there are numerous setæ which are turned toward the median orifice. Tegmen consisting of a broad chitinous area on the dorsal surface; ventral surface membranous, with only a short chitinized band to which the broad lateral lobes are attached. Lateral lobes on the ventral side of the median lobe and extending well beyond the median lobe.

In this form the basal piece is very short while on the dorsal surface there is a broad flattened dorsal piece (DP). This is the exact opposite of the condition in Dendrophagus. The two genera Dendrophagus and Brontes are closely related when the body structures are studied, being placed next to

each other by all systematists. That such a radical change should occur between the two genera seems remarkable for the number of species in both genera is small. Then it appears that the intermediate forms have disappeared. In Brontes the lateral lobes are broad and definitely separated from the tegmen by sutures. In Dendrophagus the lateral lobes are flattened and not separated from the tegmen. The internal sac of Brontes has attained a very complicated condition, with a branched flagellum present while the internal sac of Dendrophagus is simple being unmodified in any respect.

Brontes planatus (L.). Fig. 9.

Aedoeagus short and flattened dorso-ventrally. Median lobe sharply pointed at the distal end, with a large oval median orifice on the ventral surface; produced at the proximal end into a median strut (MS) which tapers to a slender strut toward the distal end. Median foramen a large opening ventrad of the median strut. Internal sac slender, without thickened areas in the distal portion but with a long area near the middle which bears short tubercules; flagellum long and branched without setæ surrounding it as in *B. dubius*. Dorsal piece (DP) on the dorsal aspect of the aedeagus, broad, shallowly and broadly emarginate at the anterior margin. Lateral lobes attached to a very short chitinous band on the ventral aspect of the aedeagus; narrow and about two-thirds as long as the basal piece.

The aedoeagus of the two species of Brontes are very similar in general shape and structure. They differ however in many minor points. The median lobe in *B. planatus* is produced into a broad median strut which is lacking in *B. dubius*. The basal piece is emarginate in *B. planatus* while it is rounded at the anterior margin in *B. dubius*. The internal sac is less complicated and the lateral lobes are narrower and shorter in *B. planatus*.

Telephanus velox Hald. Fig. 3.

Aedoeagus long and narrow, very compressed dorso-ventrally. Median lobe (ML) short, tapering to a point at the distal end, with the median orifice (MO) on the dorsal surface of the median lobe. Ventral edge prolonged into a long, slender median strut which is broadly expanded at the distal end. Median foramen (MF) a large oval opening dorsad of the median strut. Internal sac (IS) very long and slender, without a flagellum. Tegmen consisting of a broad band on the dorsal surface connected to the ventral portion by long narrow chitinous bands. Lateral lobes (LL) attached to a wider band on the ventral aspect of the aedeagus; broad, flattened, and extending well beyond the median lobe.

In this form the dorsal portion of the tegmen is much smaller than in Brontes and is placed in a much more anterior position, being connected by long narrow bands to the basal piece (BP). The median strut (MS) is very long and expanded in Telephanus while in Brontes it is short. The internal sac of Telephanus is long and slender, without flagellum; and in Brontes the internal sac bears tubercules and setæ with a branched flagellum. In both genera the lateral lobes are broad, flattened and attached to a very short basal piece.

Oryzaephilus surinamensis (L.). Figs. 6 and 7.

Aedoeagus compressed dorso-ventrally. Median lobe (Fig. 7) rounded at the distal end, broadest at the middle, tapering from the middle to a point at the proximal end. The median strut (MS) rather broad, arising from the ventral surface of the median lobe; omitted in Fig. 7. Median foramen (MF) V-shaped. On the dorsal surface close to the median foramen there are two diverging rows of large stiff bristles which become shorter toward the distal end. Median orifice, a slit-like opening at the distal end between the flattened dorsal and ventral surfaces of the median lobe. Internal sac (IS) about twice as long as the median lobe, without flagellum. Tegmen consisting of a narrow band or basal piece, on the ventral aspect, to which the lateral lobes and the dorsal piece are attached. Lateral lobes long and broad, bearing long branched setæ at the distal end; not separated by a suture from the basal piece. Dorsal piece connected to the basal piece by narrow chitinous bands.

The aedoeagus of this and the preceding form resemble each other very closely in the shape of the dorsal piece, undifferentiated internal sac, and in the similarity of shape of the median strut.

Nausibius clavicornis (Kug.). Fig. 4.

Aedoeagus long and compressed. Median lobe long and slender, with the distal end enlarged and rounded. The middle portion of the median lobe is narrow, bearing at each side a row of stout bristles. Between these rows of bristles there is a long, narrow, membranous area. Dorsal edge of the median lobe produced to form a short projection; ventral edge continued into a long median strut (MS) which is expanded at the distal end. Internal sac simple, without flagellum; about three times as long as the median lobe. Tegmen consisting of the short basal piece, lateral lobes and dorsal piece. Basal piece (BP) short and flattened, truncate at the anterior border; anterior border, emarginate between the lateral lobes. Lateral lobes shorter than in Oryzaephilus. Dorsal piece (DP) long and narrow, placed some distance from the basal piece to which it is connected by long, narrow, chitinous pieces.

The aedoeagus of this form like Oryzaephilus has two rows of stout bristles on the dorsal surface of the median lobe, though in different positions in the two genera. In Nausibius the bristles are at the sides of the median lobe while in Oryzaephilus the bristles are near the middle of the dorsal surface. As to the possible uses or function of these bristles I am unable to make any suggestions. The lateral lobes of Oryzaephilus are fused completely with the basal piece while in Nausibius the lateral lobes are separated from the basal piece as in Brontes or Telephanus. The median strut in Telephanus, Oryzaephilus and Nausibius is long slender and expanded at the distal end. The internal sac is also long and without a flagellum in these three forms.

Cathartus opaculus (Lec.). Figs. 1 and 2.

Aedoeagus small, very greatly compressed. Median lobe (ML) enlarged at the distal end; distal border thickened and forming a tooth-like projection at the middle. Median orifice a broad crescent-shaped opening on the ventral surface. Median lobe constricted, forming a median neck-like connecting area between the distal and proximal ends; proximal end expanded with the median foramen on the dorsal surface and a slender median strut (MS) continuous with the ventral edge. Internal sac simple, without flagellum. Dorsal piece of the tegmen broad and rather long. Side pieces, connecting with the basal piece, short. Basal piece, on the ventral aspect of the Aedoeagus, not as wide as the expanded part of the median lobe. Lateral lobes fused to the basal piece, very short and small with only two setæ at the end of each lateral lobe.

The aedoeagus of this form belongs to the Telephanus, Oryzaephilus, and Nausibius group because the lateral lobes and basal piece are on the ventral aspect of the median lobe, the median strut is on the ventral surface of the median lobe and the internal sac is long and simple.

Silvanus bidentatus Fab.

Aedoeagus small, resembling Cathartus very much. Median lobe broadly rounded and more heavily chitinized at the distal end with the median orifice on the ventral surface; not constricted at the middle as in Cathartus. Median foramen on the dorsal surface with the median strut projecting from the ventral margin. Median strut about the same length as in Cathartus. Internal sac simple without flagellum. Dorsal piece large, rectangular in shape, with short side pieces connecting it to the basal piece on the ventral surface. Basal piece very short consisting only of a band to which the narrow, curved lateral lobes are attached. Lateral lobes bearing two small setæ at the distal end.

The aedoeagus of Silvanus and Cathartus have a large dorsal piece, and a very short basal piece to which the lateral lobes are attached. These characters indicate that the two genera are also closely related to Brontes. But as has already been pointed out in connection with Cathartus both Silvanus and Cathartus may be included in the group with Telephanus. The aedoeagus of the five genera, Telephanus, Nausibius, Oryzaephilus, Cathartus and Silvanus shows that this is a distinct and homogeneous group.

Laemophloeus liquidus Csy. Figs. 13 and 14.

Aedoeagus of this form, small and rounded. Median lobe (ML) a broad somewhat flattened structure, very irregular, with a median groove on the ventral surface. Median foramen large, rounded, located at the proximal end of the median lobe. Distal end of the median lobe very irregularly formed with the dorsal surface produced at the middle of the anterior margin to form a pointed end. Median orifice ventrad of this point. Internal sac simple, without flagellum. Tegmen consisting of a broad dorsal piece and a smaller basal piece. Dorsal piece broad almost entirely covering the median lobe, only a narrow band around the border chitinous, the central part being membranous, broadly joined to the basal piece. Basal piece short, pointed at the anterior margin; bearing at the distal margin a heavily chitinized area which has two pair of heavy teeth one above the other. The dorsal pair is longer and conceals the ventral pair from a dorsal view. These heavy tooth-like structures are the only structures which can be compared with the lateral lobes of other forms. It seems improbable to me that these structures are homologous with the lateral lobes of Brontes.

The aedoeagus resembles Brontes in its relationship of tegmen to the median lobe, for the large membranous piece is on the dorsal aspect of the aedoeagus and the piece bearing the tooth-like structures is on the ventral surface. The Laemophleous and Brontes aedoeagus may possibly have been derived from a common ancestor which has disappeared. In other respects the aedoeagus is entirely different from the other specimens studied.

Cucujus clavipes Fabr. Fig. 5.

Aedoeagus long and slender, extending almost the whole length of the abdomen. Median lobe (ML) short and tubular with a large oval median foramen on the dorsal surface, and a long flattened median strut (MS) continuing from the ventral margin. Median orifice at the distal end of the median lobe which has two flap-like pieces folded back from the ventral margin into the median lobe; dorsal margin

deeply emarginate at each side so that the median portion is left as a short, narrow, projection. Internal sac (IS) as long as the median strut; containing a flagellum (F) which is almost as long as the internal sac. The basal piece of the tegmen is small, short, and narrowed toward the posterior border. Lateral lobes attached to the posterior margin of the basal piece, tubular in shape, short, each bearing two very long setæ and numerous shorter ones at the distal end. Dorsal piece located on the dorsal aspect of the aedeagus; reduced to a long, slender tegminal strut (IS) which is connected to the basal piece by two long, narrow chitinous bands.

Cucujus clavipes puniceus Mann.

The aedoeagus of this form resembles that of *C. clavipes* very closely in all of the structures as is to be expected in a subspecific form. The aedeagus of *C. puniceus* is distinguished from *C. clavipes* by the fact that the median lobe and lateral lobes are slightly longer in the case of *C. puniceus.*

The exceptional length of the aedoeagus of these two forms immediately sets it off from the forms previously described. Such a length of aedoeagus is only approached by *Catogenus rufus.* Aside from the extreme length of the aedoeagus the small basal piece with the rounded lateral lobes bearing two long setæ and the long tegminal strut are characters which distinctly separate the Cucujid aedoeagus from the aedoeagus of Brontes, Telephanus, and other genera of the family. It becomes clear then that the position of the basal piece on the ventral aspect of the median lobe is a family character common to all of the forms included in the family Cucujidæ.

Pediacius fuscus (Lec.). Fig. 15.

Aedoeagus long but not as slender as in Cucujus. Median lobe long, slightly curved toward the distal end with a membranous area (A) on the ventral surface and at the curve. Proximal portion of the median lobe prolonged and tapering to a rounded point at the proximal end. Median foramen (MF) occupying a large portion of the dorsal side of this prolonged area. Median orifice (MO) large, oval in shape, located on the dorsal surface of the median lobe. Ventral surface rounded and deeply emarginate. Internal sac (IS) large, resting in the trough-like proximal portion of the median lobe, with three areas of short spines; without flagellum. Basal piece forming a rather close fitting cap-piece around the ventral and distal portion of the median lobe, bearing at the end two short rounded lateral lobes. Lateral lobes articulating with the basal piece in socket-like depressions, with setæ at the distal end. Basal piece connected to the broad ventral piece of the tegmen by narrow membranous bands. Dorsal piece broad, tapering to a sharp point, covering a large part of the median foramen.

The tegmen of Pediacius is broader and more completely encloses the median lobe than in Cucujus. In Pediacius the dorsal piece is broader than the median lobe and covers over a large portion of the median foramen and the basal piece encloses the distal portion of the median lobe. In Cucujus the dorsal piece is only a narrow strut-like process, and the basal piece is a very small area on the ventral aspect of the median lobe. The median foramen of Pediacius is also much larger than that of Cucujus. The lateral lobes however are about the same size and articulate in socket-like depressions of the basal piece.

It must be remembered, however, that these likenesses are comparative, for the aedeagus of Pediacius actually measures 1.2 mm. while that of Cucujus measures 4.6 mm. in length.

Catogenus rufus Fab. Fig. 17.

Aedoeagus longer than the abdomen, and very slender. Median lobe tubular, anterior half of the tube straight with a large median foramen at the proximal end. Median strut (MS) on the ventral surface, narrow, longer than the abdomen and doubled back so that the proximal end almost reaches the median lobe. Distal half of the median lobe slightly larger, widest near the point of enlargement, gently curving to a rounded apex. Median orifice a large opening on the ventral surface. Internal sac (IS) about one-half as long as the median strut, with a flagellum which does not quite reach the median foramen. Ejaculatory duct at the apex of the internal sac, very long, small, and coiled in a spiral. Dorsal piece of the tegmen broad and covering the anterior half of the median lobe; trapezoidal in shape, widest at the base, sides straight and converging toward the apex. Basal piece on the ventral aspect of the aedeagus; small, connected to the dorsal piece by short chitinous bands. Lateral lobes flattened, extending slightly beyond the apex of the median lobe.

The broad dorsal piece, the small basal piece and the flattened lateral lobes resembles Brontes more closely than any other form in the family. When the tegmen of the two are compared it will be noted that the dorsal piece of Brontes is more nearly rectangular and that the lateral lobes are more widely separated.

Platisus sp. Fig. 10.

Aedoeagus slightly compressed laterally and about two-thirds as long as the abdomen. The median lobe is divided into a proximal and distal portion by a strong elbow curve. The proximal portion is gently curved, about one-third shorter than the distal portion, and is open on the dorsal surface for its entire length to form the median

foramen (MF). The proximal end of the internal sac (IS) is folded into this open area of the median lobe. The distal portion is also gently curved; produced on the dorsal surface beyond the median orifice to a rounded point. The median orifice is then located on the ventral surface. The internal sac (IS) bears short tubercules at the proximal end, but is without a flagellum. Basal piece (BP) short, located above the median orifice. The tegmen is completed by two narrow, long bands which extend anteriorily from the angles of the basal piece and form a slightly larger area at the elbow curve of the median lobe. The lateral lobes (LL) are short and flattened bearing numerous setæ at the distal end; distinctly separated from the basal piece by a suture

The aedoeagus of this form is slightly compressed laterally and is gently curved so that it rests on the left side with the basal piece and lateral lobes turned toward the left side of the body. I have been unable to observe the position of the aedeagus when in copula, but I have described the basal piece as being ventrad of the median lobe as is the case in other species of Cucujidæ. In other respects the aedoeagus is comparable to that of Pediacius, particularly in the structure of the proximal portion of the median lobe, the long median foramen, and the internal sac with the short tubercules on the proximal portion of the wall.

The question of the orientation of the tegmen is an important one, for, if the tegmen is dorsad of the median lobe instead of ventrad, as I have described it, the aedoeagus would show closer affinities to the Cryptophagidæ than to the Cucujidæ.

NITIDULIDÆ.

Carpophilus pallipennis (Say). Fig. 30.

Median lobe (ML) short and difficult to observe from a dorsal view, though its outline can be determined clearly from a lateral view; dorsal surface prolonged at the distal end with the oval median orifice (MO) on the ventral surface; truncate at the proximal end, with the median foramen (MF) occupying the entire end. Median strut (MS) attached at the dorsal surface of the median lobe, long, and slender with the proximal end slightly enlarged. Internal sac (IS) a simple tubular structure without modifications of any kind. Tegmen (TG) composed of two heavily chitinized pieces (which appear to be homologous with the lateral lobes of the Mycetophagidæ) fused together on the dorsal surface and united on the ventral surface by a short flattened tegminal strut (TS). Median lobe swinging in and out of the lateral lobes in a broad arc being pivoted by a shorter connecting membrane on the ventral surface and a longer membrane on the dorsal surface.

The aedoeagus of this form is peculiar in that the tegmen is a rather large piece fused at the base and divided apically.

Lobiopa setosa Hald. Fig. 34.

Median lobe (ML) short, slightly flattened dorso-ventrally, tapering to a point at the distal end and with the large transverse median orifice on the dorsal surface; truncate at the proximal end. Median foramen large, oval in shape. Median strut (MS) attached at the dorsal surface, slender, about three times as long as the median lobe. Internal sac (IS) extending to near the end of the median strut, with a short flagellum (F) at the proximal end. Tegmen composed of a broad flattened basal piece (BP) on the dorsal side of the aedeagus, connected across the ventral surface by a very short, chitinous band. Basal piece broad, curving around the median lobe at the proximal end; flattened at the distal end, and slightly emarginate. Also two short stiff bristles, and numerous finer setæ. Median lobe swings in and out of the basal piece as in Carpophilus.

Lobiopa setosa has many characters which mark it as a transitional form between Carpophilus and Glistrochilus. In the first place the internal sac in Glistrochilus is simple, in Lobiopa the internal sac has a short flagellum at the proximal end. The side pieces of the tegmen of Carpophilus have moved around more to the dorsal surface, and have almost completely fused in Lobiopa. The median lobe has been lengthened in Lobiopa. The ventral surface of the aedeagus of Lobiopa is produced so that the median orifice is on the dorsal surface instead of on the ventral surface as in Carpophilus.

Glistrochilus obtusus (Say). Fig. 33.

Median lobe short, and sharply curved, flattened at the distal end, and rounded at the proximal end, truncate at the proximal end, with a large median foramen (MF). Median strut (MS) attached at the dorsal surface, very long, and slightly enlarged at the distal end. Median orifice (MO) on the dorsal surface, extending along the curved part of the median lobe almost to the distal end. Internal sac as long as the median strut, with the proximal end enlarged to form a bulbular structure with chitinized structures at the sides. Ejaculatory duct entering at side and projecting into the internal sac. Setæ numerous, arranged in a band at one side of the internal sac. Tegmen consisting of the large Basal piece (BP) and a short chitinous band across the ventral surface which is slightly produced at the center to form a short tegminal strut (TS). Basal piece curved to fit over the median lobe; rounded and somewhat flattened at the distal end, bearing numerous setæ.

The median lobe of this species is very much larger than in Lobiopa and is strongly curved. The internal sac is enlarged at the proximal end and contains a large chitinous area with the ejaculatory duct projecting into the internal sac as a curved piece, while in Lobiopa the flagellum is not very large or com-

plicated in structure. The Basal piece is a single enlarged piece in which the fusion of the side pieces is complete.

Glistrochilus fasciatus (Oliv.).

Median lobe short and curved, but more gradually curved than in *G. obtusus;* median orifice extending to the distal end of the median lobe. Median foramen and median strut as in *G. obtusus*. Internal sac with a large irregular structure at the proximal end, the flagellum. This flagellum almost completely fills the internal sac. Proximal end of the internal sac not enlarged to form a bulb-like structure. Median lobe hinged to the basal piece as in *G. obtusus* and the other two genera of the family.

MONOTOMIDÆ.

Monotoma producta (Lec.). Fig. 35.

Aedoeagus slightly flattened dorso-ventrally and rather broad for its length. Median lobe (ML) short, and broad, truncate at the proximal end with a broad median foramen (MF) which receives the rather large internal sac (IS). A long median strut (MS) projecting from each side of the median lobe; median struts slender, about three times as long as the median lobe. Distal end of the median lobe emarginate at the middle of the ventral surface, which is slightly longer than the dorsal surface. Median orifice (MO) wide, located on the dorsal surface. Internal sac (IS) much longer than the median lobe with a thickened area at about the middle. Ejaculatory duct entering the internal sac and continuing as a spiral flagellum which extends into the internal sac for about one-fifth of its length. Basal piece (BP) flattened, not closing around the median lobe; extending beyond the median lobe and broadly rounded at the apex; without setæ.

The aedoeagus of this form is very much like that of Lobiopa in that both aedoeagi are flattened with short median lobes which are truncate at the proximal end and median orifice on the dorsal surface. The basal piece of both are flattened and shaped much alike though there is a deep median emargination in the basal piece of Lobiopa. Basal piece of Monotoma without setæ. The aedoeagus of Monotoma is readily distinguished by the two slender median struts, the thickened area in the internal sac, and the spiral flagellum at the proximal end.

PHALACRIDÆ.

Phalacrus seriatus (Lec.). Fig. 29.

Aedoeagus rather large when compared with Monotoma. Median lobe (ML) rounded, tubular, decidedly curved near the proximal end, with a very large median foramen (MF) on the ventral surface; dorsal edge produced into a broad truncate area. At the distal end the ventral

edge of the lobe projects beyond the dorsal edge, thus placing the median orifice on the dorsal face at the apex. Internal sac (IS) long, simple, without flagellum or other structures. Basal piece a single chitinized structure which partially encloses the sides of the median lobe; anterior angles connected across the ventral surface by a very short chitinous piece. Median lobe attached to the ventral piece by a short first connecting membrane so that it swings away from the basal piece in a short arc. Dorsal portion of the connecting membrane longer than the ventral portion.

The aedoeagus of this family is distinct from that of the Nitidulidæ in that the median lobe is slender, tubular, not truncate at the proximal end, and without a median strut. They are similar in that the basal piece is a single piece without lateral lobes or setæ. The median lobe is also attached to the tegmen in the same manner in the two families.

EROTYLIDÆ.

Languria bicolor Fab. Fig. 36.

Aedoeagus slightly compressed laterally, almost as long as the abdomen. Median lobe (ML) small, tubular sharply curved near the proximal end. Median foramen a large circular opening at the proximal end of the median lobe. Median strut slender, longer than the median lobe, not suddenly expanded at the end. Distal end of the median lobe truncate, with the oval median orifice (MO) at the extreme end. Internal sac (IS) about twice as long as the median lobe with a slender chitinous flagellum arising at the proximal end which is about half as long as the sac. When at rest the internal sac is withdrawn into the body so that the flagellum is not enclosed by the median lobe. Tegmen consisting of a small basal piece (BP) placed at about the middle of the median lobe; and long narrow arms connecting the small ventral piece (VP) to the basal piece. Basal piece small, short, with two long slender lateral lobes (LL) attached at the distal margin. Lateral lobes bearing a number of long setæ.

The aedoeagus of this form is very different from that of the Nitidulidæ. The median lobe in Languria is much longer, more sharply curved, and is more in the shape of a slender tube that in the Nitidulidæ. The median orifice in Languria is terminal but in the Nitidulidæ it is dorsal in position. The most pronounced difference is that the basal piece in Languria bears two long lateral lobes while in the Nitidulidæ the basal piece is large and forms a cap-piece about the median lobe. The internal sacs of the two forms are quite distinct for in Glistrochilus (the most highly developed Nitidulid) the proximal end is bulb-shaped; contains chitinous pieces, and a short

flagellum. In Languria the internal sac itself is without setæ or other structures except the long slender flagellum.

Erotylus diviiris (Lec.). Fig. 21.

Aedoeagus slightly compressed laterally resembling closely the aedeagus of Languria. Median lobe tubular, curved, truncate at the proximal end, with a long slender median strut (MS) projecting from the dorsal margin. Median foramen (MF) large and circular. Ventral margin of the distal end produced and pointed with the median orifice (MO) on the dorsal surface. Internal sac (IS) only a little longer than the median lobe with the slender flagellum (F) enlarged and divided into two equal prongs at the proximal end. Basal piece (BP) almost as long as the median lobe, and extending around the sides of the median lobe. Ventral piece of the tegmen broad, produced anteriorly so that it almost completely covers the median orifice. Lateral lobes (LL) at the distal end of the basal piece, bearing numerous setæ.

In view of the great diversity of body structure of the two forms Erotylus and Languria it is rather remarkable that the aedoeagi should agree so closely. The general shape and structure of the two are very similar. The median lobe of Erotylus is, however, larger in diameter and is almost straight with the median orifice on the dorsal surface while in Languria the median lobe is smaller, strongly curved with both the median foramen and median orifice at the ends of the median lobe. The tegmen of Languria is much smaller with the lateral connecting pieces very slender and longer than in Erotylus. The lateral lobes are distinctly separated from the basal piece in both genera while they are much longer in Languria than in Erotylus. The internal sac of Erotylus is much shorter than in Languria and the flagellum is branched at the proximal end in Erotylus.

Triplax thoracica (Say). Fig. 20.

Median lobe (ML) tubular, though slightly compressed, laterally, curved toward the middle. Median foramen large covered by the ventral piece. The median orifice (MO) on the dorsal surface, is a large opening occupying a great part of the median lobe. A long slender median strut (MS) extends from the dorsal margin of the proximal end of the median lobe. Internal sac (IS) about as long as the median lobe with a slender bent flagellum (F) attached at the apex. Tegmen consisting of a large basal piece and ventral piece. Basal piece (BP) about two-thirds as long as the median lobe and extending well up around the sides. Lateral lobes short and broad. Ventral piece (VP) broadly connected to the basal piece, produced anteriorly to form a rather broad flat tegminal strut (TS).

The aedoeagus of this form in general resembles that of the two forms previously described. But the broad flat tegminal strut, the bent flagellum, the enlarged proximal end of the median strut, and the very large median orifice are characters in which Triplax differs from Erotylus. The lateral lobes are also shorter than in Erotylus.

Agithus genuinatus (Lec.). Fig. 19.

Median lobe (ML) long and slender, sharply curved near the proximal end and with a large circular median foramen at the proximal end. Median strut (MS) extending from the dorsal edge, slender and slightly expanded at the extreme end. Median lobe (ML) gradually larger toward the distal end, with the dorsal surface slightly produced and pointed, thus placing the median orifice on the ventral surface. Internal sac (IS) slender and simple, without flagellum. Basal piece (BP) long; almost enclosing the sides of median lobe, with shorter rather broad lateral lobes attached at the distal end. Ventral piece slightly produced but not entirely covering the median foramen.

The median lobe of this form is more like Languria in that it is tubular, and strongly curved near the proximal end while Triplax and Erotylus are stouter and less curved. The median strut is expanded at the end in both this form and in Triplax. The other members of the family except Tritoma have a flagellum in the internal sac. Internal sac in Agithus and the other members of the family gradually decreasing in size toward the proximal end so that it is impossible to distinguish where the ejaculatory duct joins the internal sac.

Tritoma humeralis Fabr. Fig. 18.

Median lobe (ML) short, larger in diameter than in *Agithus*, slightly curved, produced at the distal end into a rounded point on the ventral surface, with the sides slanting back toward the dorsal surface. Median orifice (MO) large, located on the dorsal surface of the median lobe. The small median foramen (MF) at the proximal end of the median lobe not occupying the entire area. Median strut (MS) at the dorsal edge of the median lobe, slightly longer than the median lobe, expanded at the distal end. Internal sac (IS) small, without flagellum. Basal piece (BP) about two-thirds as long as the median lobe, sides extending around the median lobe, with two short lateral lobes at the distal end. Ventral piece pointed at the anterior border, extending over the median foramen, and broadly connected to the basal piece.

The aedoeagus of *Tritoma humeralis* is shorter than that of any of the other four genera. The median lobe is short, only slightly curved, and produced at the distal end, resembling

Triplax thoracica. The internal sac is without a flagellum as in *Agithus genuinatus*. Lateral lobes of Tritoma similar to the lateral lobes in *Triplax thoracica*.

The members of the family Erotylidæ are shown to be closely related to each other by the genitalia of the male and form a compact natural group. The genus Languria is also shown to be very closely related to the other members of the family.

CRYPTOPHAGIDÆ.

Antherophagus ochraceus Melsh. Fig. 22.

Median lobe (ML) short, rounded, ventral surface much longer than the dorsal surface, thus placing the median orifice (MO) on the dorsal surface. Proximal end of the median lobe tapering into a broad, slightly curved, median strut (MS) on the dorsal surface, ventral surface with a large oval opening for the reception of the internal sac. The internal sac (IS) without flagellum. Tegmen consisting of three parts, the narrow ventral piece, broad basal piece and lateral lobes. Ventral piece (VP) reduced to a very short chitinous band, which is pointed at the middle and connected to the anterior angles of the basal piece. Basal piece (BP) almost as long as the median lobe with large triangular lateral lobes at the distal end which bear long setæ.

Cryptophagus croceus Zimm. Fig. 12.

Aedoeagus smaller and shorter than in *Antherophagus ochraceus*. Median lobe (ML) short, rounded with the ventral surface longer than the dorsal surface and rounded at the distal end. Median orifice (MO) large, located on the dorsal surface and near the rounded point. Proximal end of the median lobe produced into a large median strut which is gently curved. Internal sac (IS) simple, without flagellum. Basal piece (BP) of the tegmen much shorter than the median lobe and only partially enclosing the median lobe. Lateral lobes (LL) small, triangular pieces attached to the distal end of the basal piece, and bearing short setæ. Ventral piece reduced to a chitinized band which completes the ring around the median lobe.

The aedoeagi of these two genera differ only in details. The basal piece is shorter and the lateral lobes are smaller in Cryptophagus than in Antherophagus. The median strut is curved throughout in Antherophagus while it is almost straight in Cryptophagus. The ventral piece is reduced in both forms to a very short chitinous band which connects the angles of the basal piece.

The Cryptophagid aedoeagus is clearly similar in structure to the Erotylidæ. The median strut in the Crytophagidæ

has become expanded so that it encloses the median foramen while in the Erotylidæ the median strut is a very slender structure. The tegmen is also very similar though the ventral piece is reduced and the lateral lobes are expanded into flattened triangular pieces in the Cryptophagidæ.

ENDOMYCHIDÆ.

Endomychus bigutattus Say. Fig. 24.

Aedoeagus so strongly curved that it is crescent shaped. Median lobe (ML) well chitinized, tubular, with the proximal end slightly expanded, and truncate, thus making the median foramen terminal. At the distal end of the median lobe the ventral margin extends beyond the dorsal edge placing the median orifice on the dorsal surface. Median orifice long, elliptical in shape with the internal sac partially extruded. Internal sac short and tubular with short slender flagellum (F) at the apex. Internal sac not distinctly distinguishable from the ejaculatory duct. Tegmen consisting of a short chitinous piece which encircles the median lobe. An irregular tegminal strut extending from the ventral face of the tegmen, expanded at the end and articulating with the proximal end of the median lobe. No lateral lobes present.

The crescent shaped tubular median lobe and the short tegmen without lateral lobes characterize the aedeagus of this form.

COCCINELLIDÆ.

The aedoeagus of the Coccinellidæ lies on one side with the lateral lobes toward the left side of the abdomen. The curvature of the aedeagus requires that it lie on one side and when extended it turns through an angle of ninety degrees in order to come in contact with the female genitalia. The curvature and bulk of the aedeagus would require some such arrangement. In the extended condition the lateral lobes are dorsad of the median lobe and are described as being dorsal in the following descriptions.

In specimens observed in copula the lateral lobes serve as claspers being placed on the outside of the abdomen of the female. In other families the lateral lobes are supposed by Sharp and Muir to enter the vagina and serve as distensors.

The Coccinellid aedoeagus differs from all the other families of Coleoptera in that it has developed another chitinous area which surrounds the median lobe. This area is definitely a part of the tegmen and I have called it *basal lobe* since it is an

extension of the basal piece of the Tegmen. The basal lobe becomes more and more complex and I have arranged the descriptions in order from the simple to the complex type of structure.

HYPERASPINI.

Hyperaspis signata (Oliv.). Figs. 37 and 38.

Median lobe (ML) long, slender, curved and tubular with the proximal end flattened. Median foramen (MF) a long opening extending the length of this flattened area. Median orifice at the distal end of the median lobe. Internal sac a simple straight tube without flagellum. Tegmen forming a complete ring around the median lobe. Basal piece (BP) heavily chitinized, forming an almost complete circle, which is completed by the tegminal strut (TS) on the ventral side. Tegminal strut slender, articulating with the expanded portion of the median lobe. Lateral lobes (LL) at the sides of the basal piece and appearing to be continuation of the basal piece. Basal lobe (BL) between the lateral lobes and apparently a median extension of the basal piece.

It is this basal lobe upon which Vierhoeff (1893) based his separation of the Coccinellidæ from the remainder of the Coleoptera as the suborder Siphonophora. Figures 38 and 40 show this area to be definitely a part of the tegmen and not the "penis" (which corresponds to the median lobe).

Brachyacantha ursina Fabr. Fig. 39.

Expanded portion of the median lobe subrectangular in shape with the median foramen (MF) extending the length of this area. At the dorsal surface there is a thin chitinous area (A) which is also found in Coccinella. Median lobe tapering to a small opening at the distal end. Basal lobe (BL) broad, not curved around the median lobe, slightly longer than the lateral lobes. Lateral lobes (LL) large and concave. Tegminal strut (TS) attached to the ventral face of the tegmen and articulating with the expanded proximal end of the median lobe.

CHILOCORINI.

Chilocorus bivulnerus (Muls.). Figs. 40 and 41.

Median lobe (ML) long and slender, with the proximal end expanded in such a manner as to form a T with the median lobe. Basal piece (BP) large, and cylindrical. Lateral lobes (LL) slender, extending to the end of the median lobe. Basal lobe (BL) as long as the lateral lobes, pointed at the distal end. Figure 40 also shows the basal lobe to be a continuation of the tegmen and not a part of the median lobe.

COCCINELLINI.

Ceratomegilla fuscilabsis Muls. Fig. 42.

Median lobe (ML) long and tapering to a small distal end. Flattened portion of the median lobe deeply emarginate to receive the tegminal strut. Basal piece (BP) long and circular. Lateral lobes (LL) slender. Basal lobe (BL) broad, curving around the median lobe but not meeting on the mid ventral surface.

Adalia bipunctata (L.). Fig. 43.

Flattened portion of the median lobe subrectangular and slightly emarginate to receive the tegminal strut (TS). Median lobe tapering toward the distal end then suddenly enlarged at the end. Basal piece (BP) short. Lateral lobes (LL) short and slightly curved. Basal lobes (BL) slightly longer than the lateral lobes, sides closely approaching each other on the dorsal surface producing a keel-like structure.

Anatis quadridecimpunctata (Oliv.). Fig. 44.

Aedoeagus long and slender. Proximal end of median lobe deeply emarginate, medium sized, irregular in outline. Median lobe (ML) tapering toward distal end and suddenly bent ventrad. Tegmen much smaller than in Coccinella. Lateral lobes (LL) and basal lobe (BL) of equal length. Basal lobe irregular in shape with lateral margins widely separated.

Coccinella perplexa Muk. Fig. 45.

Proximal portion of the median lobe very much larger than in Anatis with the median foramen (MF) extending its whole length; tegminal strut fitting into the emargination near the center. Median lobe tapering to a small distal end. Tegmen large with the anterior dorsal surface of the basal piece (BP) prolonged to a sharp point. Lateral lobes (LL) shorter than the basal lobe. Basal lobe (BL) broad with the sides folding around the median lobe, but widely separated on the ventral surface, pointed at the distal end.

Coccinella novemnotata Hbst. Fig. 46.

The aedoeagus of this species is longer and less bulky than *C. perplexa*. Proximal end of median lobe (ML) large with a thin chitinized area (A) on the dorsal margin. Median lobe about the same size throughout its whole length. Basal piece (BP) produced at the anterior margin to a point. Basal lobe (BL) longer than the lateral lobes, not extending around the median lobe.

Coccinella quinquenotata Kby. Fig. 47.

Aedoeagus long, and large. Proximal end of the median lobe (ML) expanded transversely, irregular in outline, with the flattened area (A) at the dorsal margin. Median lobe long, becoming slightly larger at the distal end. Basal piece extending further craniad than in the two species just described. Lateral lobes (LL) as long as the Basal lobe

(BL). Basal lobe enlarged and deeply emarginate at the distal end, surrounding the median lobe but not fused on the ventral surface, dorsal surface more heavily chitinized than the lateral surface.

Olla abdominalis plagiata Csy. Fig. 48.

Proximal end of the median lobe (ML) narrowly flattened, extending in a dorso-ventral direction, with a broad emargination for the reception of the tegminal strut (TS). On the dorsal side the thin chitinized area (A) is present as in Coccinella but much smaller. Median lobe (ML) long; about the same size throughout, except near the distal end. Distal end divided into two subequal prongs, the dorsal prong being bent backward over the basal lobe (BL) and fitting into a groove in the basal lobe, ventral prong bent in a ventrad direction and bearing the median orifice (MO). Basal piece produced and pointed anteriorily. Basal lobe long, almost surrounding the median lobe but not fused on the ventral surface, shaped much as the basal lobe in Epilachna. Lateral lobes (LL) as long as the basal lobe, expanded at the distal end.

The members of the tribe Coccinellini show clearly a gradual increase in complexity of the aedoeagus from *Ceratomegilla fuscilabris* through the series in the order of the above descriptions to the larger aedeagus. And more complex condition displayed in *C. quinquenotata* and *Olla abdominalis*. The enlarged distal end of the median lobe of *Adalia bipunctata* may be an evagination of the internal sac. It is a constant condition for several specimens were examined. *Olla abdominalis plagiata* definitely belongs to the tribe Coccinellini but it also suggests certain tendencies toward Epilachna. Such characters as the length of the median lobe, basal lobe, and lateral lobes show resemblances to the same characters in Epilachna.

HIPPODAMINI.

Hippodamia parenthesis (Say). Fig. 51.

Median lobe (ML) curved very sharply near the proximal end, slightly expanded on the ventral side and having the tegminal strut (TS) rest against this expansion. Median foramen circular and at the proximal end of the median lobe. A small flap-like projection (A) extends from the ventral margin. Median lobe about the same size throughout except near the distal end where it suddenly tapers to a small median orifice (MO). Basal piece (BP) large, and pointed on the dorsal surface, with a short stout tegminal strut (TS) projecting from the ventral surface. Tegminal strut expanded at the distal end and emarginate to form a groove for the median lobe. Lateral lobes (LL) broad Basal lobe (BL) extending around the median lobe and fused on the ventral surface thus completing a second ring or tube around the median lobe. Dorsal and lateral surfaces of the basal lobe well chitinized.

Hippodamia convergens (Guer.). Fig. 52.

Median lobe (ML) shaped much like that of *H. parenthesis;* not expanded at the proximal end. Basal piece (BP) produced to a point anteriorly, with the basal lobe extending around the median lobe and completely fused on the ventral surface to form the second chitinous ring around the median lobe. On the lateral surfaces this structure is deeply emarginate at the distal end, with the dorsal and ventral surface sharp pointed. Tegminal strut (TS) enlarged toward the distal end and grooved to receive the median lobe. Lateral lobes (LL) narrow.

Hippodamia tridecempunctata (Linn.). Fig. 53.

The aedoeagus of this form is very irregular in shape. Median lobe as in the two species above. Basal piece (BP) large, not produced anteriorly. Basal lobe large, tubular, and completely surrounding the median lobe, emarginate at the distal end. Lateral lobes (LL) broad and without setæ.

Casey (1899) and others place Hippodamia, Ceratomegilla and other genera in the tribe Hippodamini. Leng (1920) and Daborensky (1926) place all of these genera in the tribe Coccinellini. The following characters of the aedoeagus however are sufficient to separate Hippodamia as a distinct tribe: proximal end of the median lobe not expanded, median orifice terminal and rounded, proximal end of median lobe with a small flag-like projection from the ventral surface, basal lobe completely fused on the ventral surface.

EPILACHNINÆ.

Epilachna borealis (Fab.). Fig. 49.

Median lobe (ML) curved into an S-shaped slender tube about the same size throughout, proximal end slightly expanded. Basal piece (BP) truncate at the margin with long slender lateral lobes (LL). Tegminal strut (TS) short grooved for articulating with the proximal end of the median lobe. Basal lobe (BL) long, fitting closely around the median lobe, sides not fused on the ventral surface to complete the tube.

Epilachna corrupta (Muls.). Fig. 50.

The proximal end of the median lobe of this species is not expanded but a small projection from the ventral side of the median lobe serves as a stop for the tegminal strut. Basal lobe more strongly curved and the tegminal strut more irregular in shape than in *C. borealis.*

The aedoeagus of the two species of Epilachna differ quite markedly from that of the other Coccinellidæ in the reduction of the expanded proximal end of the median lobe, and the

recurved condition of the median lobe. This second curve of the distal portion of the median lobe also requires a like curve of the basal lobe in *C. corrupta* for the basal lobe fits more closely around the median lobe than in *C. borealis*. In the tegmen other very distinct differences will also be noticed. First, the tegmen as a whole is slender and much less bulky that in the species of Coccinella and Hippodamia. Second, the anterior border of the basal piece is not prolonged and pointed but is shorter and truncate in Epilachna. Third, the lateral lobes are longer and narrower in Epilachna than in Coccinella.

The structure of the aedeagus of Epilachna and Hippodamia indicates that there were two lines of development from the Coccinella aedoeagus. *Olla abdominalis plagiata* shows a tendency toward the slender condition with a reduction of the flattened proximal end of the median lobe and a lengthening of the basal lobe to resemble the basal lobe of Epilachna somewhat. In the genus Hippodamia the aedeagus remains broad with an expanded piece, and with a very large, irregular, and tubular basal lobe. The lateral lobes also remain broad and short as in Coccinella. Thus Epilachna may be derived from a form like *Olla abdominalis plagiata* while Hippodamia may be derived from a form like Coccinella.

GENERAL DISCUSSION.

The structure of the aedoeagi described are such that they may be divided into four groups. The first group is characterized by the tegmen not forming a complete ring around the median lobe. The tegmen is also on the ventral aspect of the median lobe. This group is represented by the Mycetophagidæ. In the second group the tegmen forms a complete ring around the median lobe and the lateral lobes attached to the basal piece are on the ventral aspect of the median lobe. The Cucujidæ are an example of this type of aedoeagus. In the third group the basal piece is absent, and the lateral lobes are fused to form a single chitinous area on the dorsal aspect of the median lobe. The Nitidulidæ, Monotomidæ, and Phalachridæ belong to this group. The fourth and last group is characterized by the aedoeagus lying on its side with the tegmen forming a ring around the median lobe, and the lateral lobes present in a dorsal or latero-dorsal position. To this group belong the Erotylidæ, Cryptophagidæ, Endomychidæ, and Coccinellidæ.

Sharp and Muir have applied the term trilobe to the first type of aedoeagus. Besides the characters given above the aedoeagus of this type has the lateral lobes attached to the basal piece by a thin membrane which allows them to swing away from the median lobe in a slight arc. The basal piece is usually broad and is attached to the median lobe by a short membrane which causes the two parts to move as one. The median lobe is usually a simple straight tube enclosing an unmodified internal sac. This type of aedoeagus is considered most primitive because of the simplicity of the median lobe, and because transitions from this type to a more complicated type is easier than from any other type of aedoeagus. The family Mycetophagidæ is the only family I have studied which possesses this type of aedoeagus.

The second type of aedoeagus represented by the Cucujidæ is of a rather heterogeneous nature. The genera Hemipeplus, Inopeplus and Prostomis in fact have an aedoeagus which relates them directly to the Mycetophagidæ, for the tegmen is not completed around the median lobe. If we consider the aedoeagus of these genera alone they should be separated as a distinct family from the Cucujidæ. But if we examine the body characters of these three genera it is impossible to find characters which will separate them from the Cucujidæ. The aedoeagus also fails to furnish characters which would support placing Hemipeplus, Inopeplus, and Prostomis with Laemophloeus to form the family Laemophlidæ of Böving. The aedoeagus of Laemophloeus differs from that of the first three forms in every respect, while according to the larval characters Hemipeplus and Inopeplus should be included in the same subfamily with Laemophloeus.

In the genus Dendrophagus we have a very good example of how the bilobed type of aedoeagus may be derived from the trilobe type. The lateral lobes are not separated from the large basal piece by a membrane but are solidly fused to it, and a short chitinized band is formed across the dorsal surface so that the tegmen completely encircles the median lobe. Then it is not necessary to imagine the lateral lobes moving around to the dorsal surface to derive the cucujid aedeagus from the trilobe type. The connecting membrane between the median lobe and the tegmen has become lengthened to allow movement of the median lobe in the tegmen which completes

the fundamental changes required for the production of the cucujid type of aedeagus.

The short dorsal piece in Dendrophagus is produced anteriorily in Brontes concomitant with a reduction of the basal piece and a separation of the lateral lobes. These changes produce an aedeagus which resembles Dendrophagus very little superficially. It must be remembered, however, that the lateral lobes are still on the ventral aspect of the aedeagus. The shape of the median lobe and internal sac of these two forms is also very different, more different in fact than the same structures in the families Nitidulidæ and Monotomidæ. There is certainly a great enough diversity in the genitalia to justify separating Brontes and Dendrophagus as distinct families. The body characters or larval characters, however, do not indicate a wide enough separation of the two genera to justify separate family rank.

When we consider the tegmen of Telephanus we find that it may be readily derived from some form like Brontes by a lengthening of the chitinous connections between the dorsal and ventral parts. The median lobe in Brontes is also simple enough to allow the assumption that the two came from a common ancestor. Furthermore, the aedoeagus of Telephanus is more closely related to Brontes than Brontes is to Dendrophagus. Then if we follow Böving in placing Telephanus in the family Silvanidæ, Dendrophagus should also be placed in a new family.

The aedoeagus of Oryzaephilus and Nausibius represents a very high degree of specialization of the median lobe, but the general structure of the tegmen resembles that of Telephanus so closely that they may be placed together.

The aedoeagi of Silvanus and Cathartus are very small, but the dorsal portion of the tegmen resembles that of Brontes very closely. The position of the lateral lobes and the shape of the median strut shows Silvanus and Cathartus to be a member of the same group as Telephanus.

In the genus Laemophloeus the aedoeagus is flattened dorsoventrally with a broad dorsal piece covering the median lobe, and the tooth-like structures representing lateral lobes on the ventral aspect, as in Brontes. The small size and very peculiar structure of the aedoeagus makes it difficult to determine the position of this genus but it seems least out of place near Brontes.

In the case of Cucujus the basal piece and lateral lobes are on the ventral aspect of the aedoeagus as in the other members of the family. The very long slender aedoeagus makes it difficult to place this genus with certainty. It is possible that Cucujus is also derived from some form like Brontes. A great lengthening of the aedoeagus is the principal change required.

The aedoeagus of Pediacius resembles that of Cucujus in many respects, particularly in the tegmen, but the difference in length of the two aedoeagi causes the two aedoeagi to appear rather distantly related.

Catogenus resembles Brontes in the size, shape and position of the parts of the tegmen very closely.

In the case of Platisus the determination of its affinities depends upon the view taken as to the position of the tegmen. I have described the tegmen as ventrad of the median lobe because the other characters of the aedoeagus show it to be related to Pediacius which has the tegmen ventrad of the median lobe. If, however, the tegmen is dorsal Platisus is closely allied to the Cryptophagidæ.

The family Cucujidæ includes a group of genera which show such a wide variation in the structure of the aedoeagus that it is impossible to determine with any degree of certainty the affinities of the various genera. If we begin separating the genera into families as indicated by the genitalia it would become necessary to give practically every genus family rank. Then we are confronted with the alternative of leaving the family as a conglomerate of widely separated forms or giving each genus family rank. I have also attempted to arrange the genitalia in groups which would correspond to Böving's arrangement of the larvæ.

Such a division of the family upon larval characters would require the separation of the genera Silvanus, Cathartus, Oryzaephilus, Nausibicus, and Telephanus as a distinct family while Dendrophagus and Brontes would remain in the same subfamily. If the genitalia are considered it is obvious that Dendrophagus differs from Brontes as much if not more than Telephanus differs from Brontes. The same thing is true of the genera Cucujus, Pediacus and Platisus, each being distinctly different from the other. These genera would all be placed together when the larval and adult characters are considered. But the genitalia of Platisus and Cucujus show a much greater

difference than the genitalia of Cryptophagus and Erotylus. When the body characters are considered it is impossible to find characters which will separate Platisus from Cucujus or Dendrophagus from Brontes as separate families. Where such conditions prevail it seems that less confusion will result if we do not attempt to separate the old family Cucujidæ. So I propose to recognize it as a very primitive family in which a great many intermediate forms have disappeared.

The third group represented by the Nitidulidæ, Monotomidæ and Phalacridæ is characterized by having the greater portion of the tegmen on the dorsal aspect of the aedoeagus.

The aedoeagus of Carpophilus represents the primitive type of this group. The tegmen of Carpophilus may be derived from the trilobe type of aedoeagus by three changes; first the disappearance of the basal piece. This is not an impossible change because a similar change takes place in Brontes. Second the lateral lobes are fused on the dorsal surface to form a new basal piece. The fusion of the lateral lobes on the dorsal surface is a natural result of the reduction of the basal piece in order to hold the tegmen together. This is not a great step because the lateral lobes approximate each other on the dorsal surface. Third, the formation of the tegminal connection on the ventral surface is probably the result of chitinization of the membranes which connects the aedeagus to the body.

In Lobiopa the fusion of the lateral lobes on the dorsal surface is almost complete with only a slight emargination at the apex to indicate the separated condition in Carpophilus. Accompanying this fusion on the dorsal surface the tegmen has drawn away from the mid-ventral line leaving a short connecting piece across the ventral surface.

Glistrochilus represents the stage in which the fusion is complete. In this form the tegmen is a single large cap-piece fitting rather closely over the curved dorsal surface of the median lobe.

The internal sac of these three genera also gradually increases in complexity. Like Mycetophagus the internal sac of Carpophilus is undifferentiated. In Lobiopa there is a short simple flagellum at the proximal end. Finally in Glistrochilus the ejaculatory duct empties upon a short curved flagellum, the end of the internal sac is bulb-shaped, and numerous setæ are present.

The tegmen of Monotoma is broad and flattened on the dorsal surface without an emargination at the apex, and the ventral portion of the tegmen is produced anteriorily so that it is much longer than in Lobiopa. The structure of the median lobe and internal sac of the Monotomidæ and Nitidulidæ is quite different but the structure of the tegmen in the two families show such strong resemblances that I believe them to be closely related.

The Phalacridæ also belong in this group, and was probably derived from some form like Lobiopa. The basal piece of Phalacrus like Monotoma is not emarginate at the apex, but is a single piece covering the greater part of the dorsal surface of the median lobe.

The fourth group composed of the Cryptophagidæ, Erotylidæ, Endomychidæ, and Coccinellidæ, is distinguished by having the aedoeagus widely curved and resting on the left side within the abdomen. When the aedoeagus is extruded it turns through an angle of ninety degrees as described in the case of the Coccinellidæ, so that the tegmen is dorsad of the median lobe in the four families of this group.

The families included in this group show very little affinity for the two preceding groups, but the three agree, however, in one respect. The tegmen, though variable in shape, position and structure forms a complete ring around the median lobe.

The characters used to distinguish this group bring together four families which vary widely in the shape of the tegmen and median lobe. In the Erotylidæ and Cryptophagidæ the basal piece covers a greater part of the median lobe. Both families have median struts extending from the dorsal margin of the median lobe. The internal sac in both families is tubular and continuous with the ejaculatory duct but the sac of the Cryptophagidæ represents the simpler condition. In this family the flagellum is not present while in the Erotylidæ, with only two exceptions, the flagellum is present as a stout tubular structure, which is branched at the proximal end in Erotylus.

In the case of the Endomychidæ the tegmen is reduced to a chitinous band which encircles the median lobe, and is without any indication of the lateral lobes. Like the Cryptophagidæ and Erotylidæ the internal sac is continuous with the ejaculatory duct, and like the Erotylidæ it contains a tubular flagellum.

The Coccinellidæ are distinct from the other families in developing the extra basal lobe on the tegmen. In forms figured by Sharp and Muir and in *Hyperaspis signata* the basal lobe is a simple area about as long as the lateral lobes. This piece gradually becomes larger and more complex until it meets on the ventral surface in Hippodamia to form a complete tube around the median lobe. The median lobe in the Coccinellidæ is also specialized in a different direction from the other Coleoptera. The expanded proximal end of the median lobe occurs in all of the genera except Hippodamia. This area is broadly open to receive the small simple internal sac and is attached to the tegminal strut by muscles.

Verhoeff (1895) considered the presence of this tube to be of such importance that he proposes that the Coccinellidæ be placed in the suborder Siphonophora and all the other Coleoptera in the suborder Asiphona. Verhoeff's conclusions result as a different conception of the structure of the aedeagus. The term "penis" as used by Verhoeff is equivalent to the term "median lobe" of Sharp and Muir. Verhoeff considers the basal lobe to be the "penis" enclosing a structure he calls the "Siphon." The basal lobe is a part of the tegmen and is not an independent tube. Figure 38 and 40 show this structure to be clearly a part of the tegmen enclosing the median lobe. Then the Coccinellid aedoeagus is not composed of three rings as Verhoeff thought and his division of the Coleoptera can not be maintained.

EXPLANATION OF ABBREVIATIONS.

BP.....Basal piece.
BL.....Basal lobe.
CM_1.....First connecting membrane.
CM_2.....Second connecting membrane.
DP.....Dorsal piece.
EJ.....Ejaculatory duct.
F.....Flagellum.
IS.....Internal sac.
MF.....Median foramen.
ML.....Median lobe.
MO.....Median orifice.
MS.....Median strut.
LL.....Lateral lobes.
SP.....Spicule.
TG.....Tegmen.
TS.....Tegminal strut.
9SG.....Ninth abdominal segment.
10SG....Tenth abdominal segment.

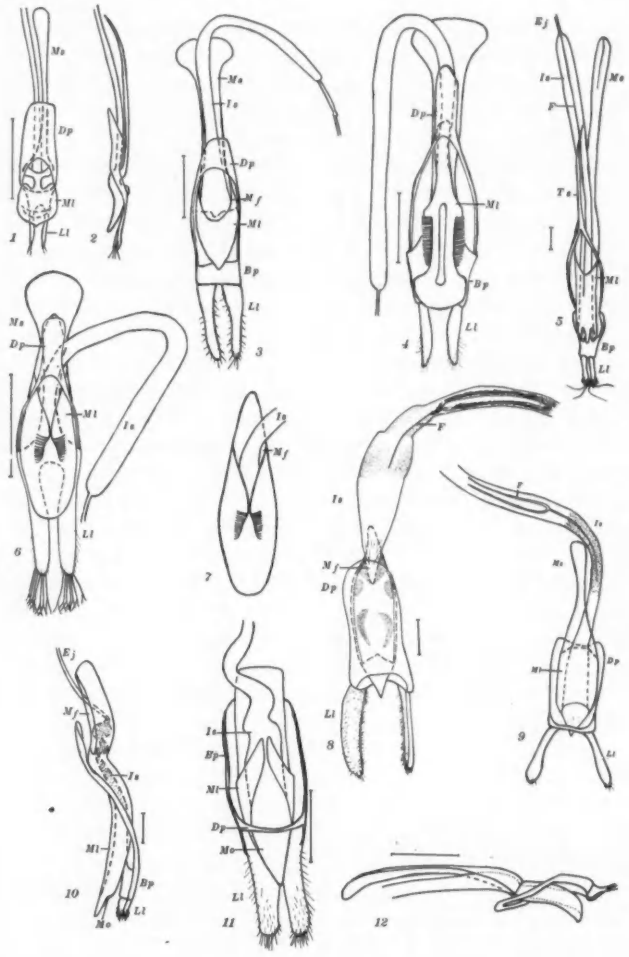

Fig.
1. *Cathartus opaculus* Lec. Dorsal view.
2. *Cathartus opaculus* Lec. Side view.
3. *Telephanus velox* Hald. Dorsal view.
4. *Nausibius clavicornis* (Kug.). Dorsal view.
5. *Cucujus clavipes* Fabi. Dorsal view.
6. *Oryzaephilus surinamensis* (L.). Dorsal view.

Fig.
7. *Oryzaephilus surinamensis* (L.). Median lobe.
8. *Brontes dubius* Fabi. Dorsal view.
9. *Brontes planatus* (L.). Dorsal view.
10. *Platicus* sp. Side view.
11. *Dendrophagus Cygnaei* Mann. Dorsal view.
12. *Cryptophagus croceus* Zimm. Side view.

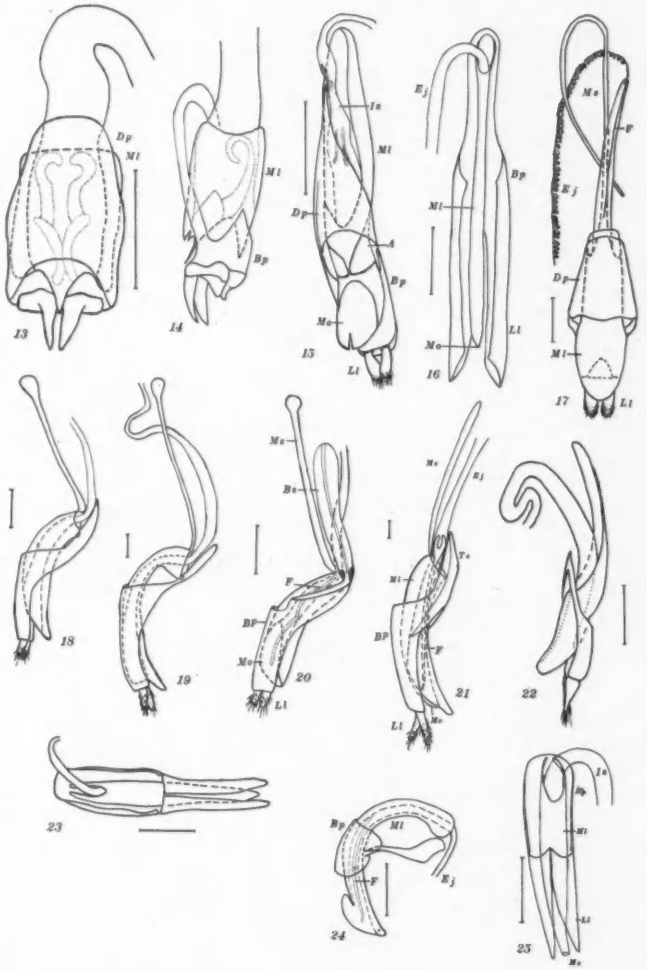

Fig.
13. *Laemophloeus liquidus* Csy. Dorsal view.
14. *Laemophloeus liquidus* Csy. Side view.
15. *Pediacus duscus* Lec. Dorsal view.
16. *Hemipeplus marginipennus* Lec. Dorsal view.
17. *Catogenus rufus* Fabr. Dorsal view.
18. *Triloma humeralis* Fabr. Side view.
19. *Agithus genuinatus* Lec. Side view.
20. *Triplax thoracica* Say. Side view.
21. *Erotylus diviiris* Lec. Side view.
22. *Antherophagus ochraceus* Melsh. Side view.
23. *Typhoe fumata* (L.). Dorsal view.
24. *Endomychus biguttatus* Say. Side view.
25. *Mycetophagus flexuosus* Say. Dorsal view.

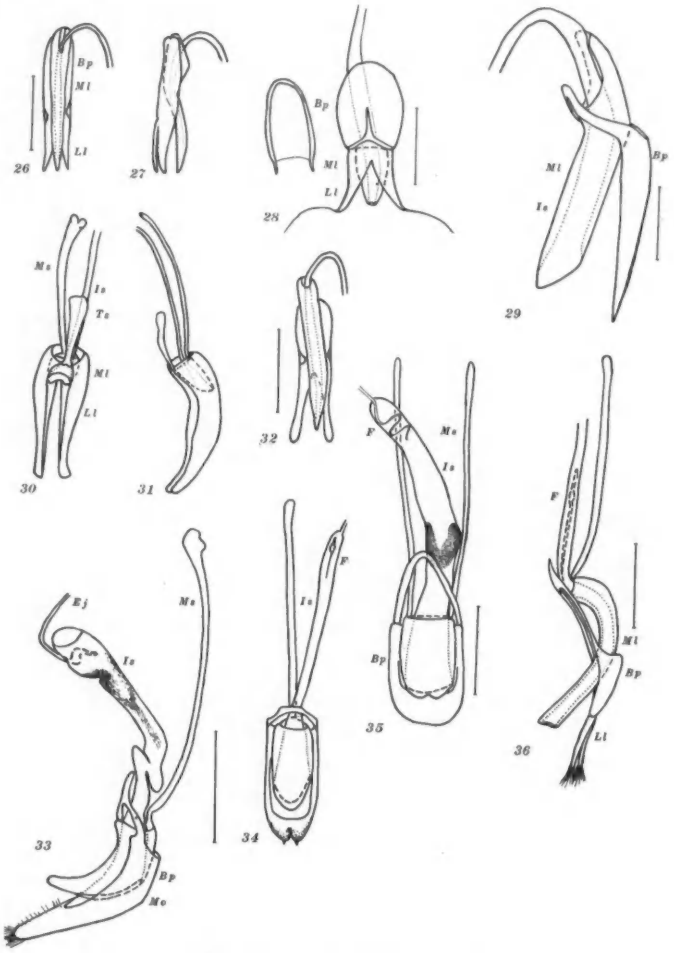

Fig. 26. *Inopeplus immunda* Reit. Dorsal view.
Fig. 27. *Inopeplus immunda* Reit. Side view.
Fig. 28. *Prostomis mandibularis* Fabr. Ventral view.
Fig. 29. *Phalachrus seriatus* Lec. Side view.
Fig. 30. *Carpophilus pallipennis* (Say). Dorsal view.
Fig. 31. *Carpophilus pallipennis* (Say). Side view.
Fig. 32. *Inopeplus reclusa* Lec. Dorsal view.
Fig. 33. *Glistrochilus obtusus* (Say). Side view.
Fig. 34. *Lobiopa setosa* Hald. Dorsal view.
Fig. 35. *Monotoma producta* Lec. Dorsal view.
Fig. 36. *Languria bicolor* Fabr. Side view.

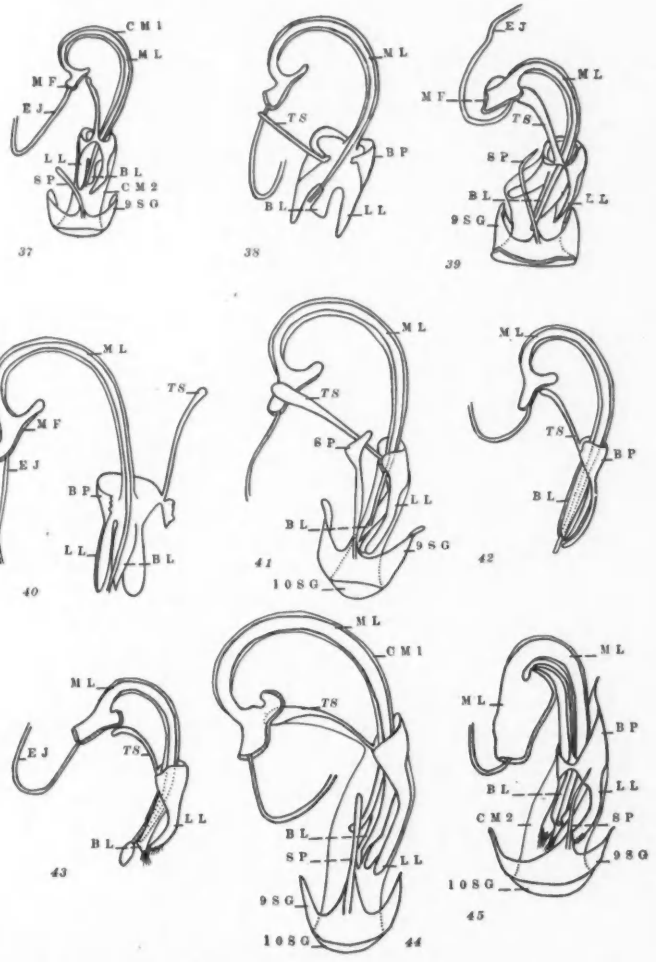

Fig. 37. *Hyperaspis signata* (Oliv.). Dorsal view.
Fig. 38. *Hyperaspis signata* (Oliv.) with the tegmen pulled apart to show the basal lobe.
Fig. 39. *Brachyacantha ursina* Far. Dorsal view.
Fig. 40. *Chilochorous bivulnerus* Muls. with the tegmen pulled apart to show the basal lobe.
Fig. 41. *Chilochorous bivulnerus* Muls. Side view.
Fig. 42. *Ceratomegilla fuscilabris* Muls. Side view.
Fig. 43. *Adalia bipunctata* (L.). Side view.
Fig. 44. *Anatis quadridecempunctata* (Oliv.). Side view.
Fig. 45. *Coccinella perplexa* Mubs. Side view.

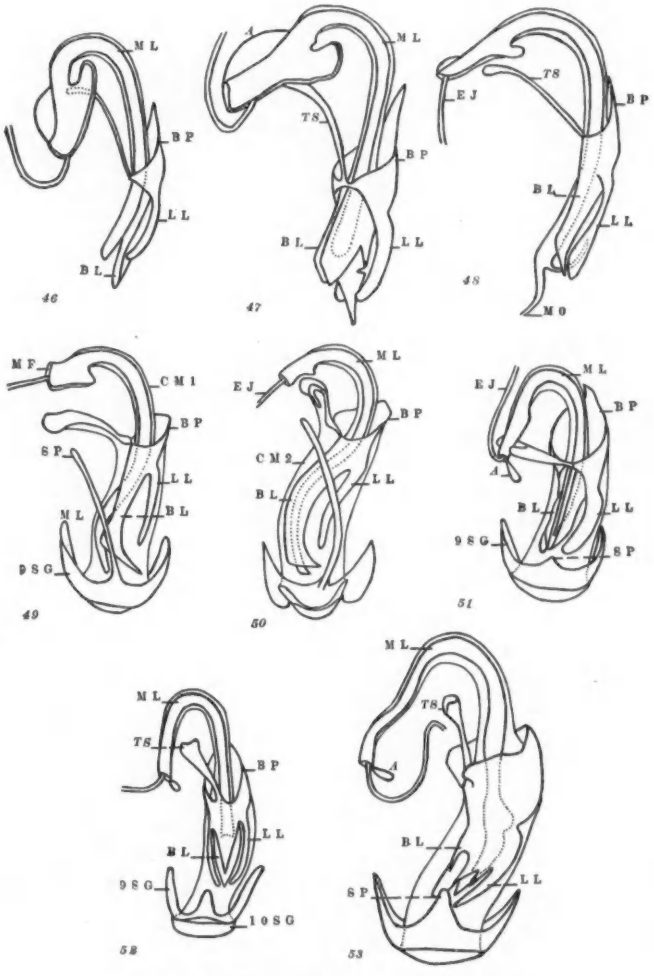

Fig. 46. *Coccinella novemnotata* Hbst. Side view.
Fig. 47. *Coccinella quinquenotata* Kby. Side view.
Fig. 48. *Olla abdominalis plagiata* Csy. Side view.
Fig. 49. *Epilachna borealis* Fabr. Side view.
Fig. 50. *Epilachna corrupta* Muls. Side view.
Fig. 51. *Hippodamia parenthesis* (Say). Side view.
Fig. 52. *Hippodamia convergens* (Guen.). Side view.
Fig. 53. *Hippodamia tridecempunctata* (L.). Side view.

SECTION II

Comparative Study of the Venation of the Cucujidae and Related Families.

The wing veins of the Coleoptera present a problem upon which there has been little agreement by those who have attempted to homologize the venation. This disagreement has arisen because of several reasons, the chief reason being the very unique and complicated course of the veins, which requires very much more study in order to reach correct conclusions than is required by other orders of insects. This unique form of venation is further complicated by the transverse folding of the wings which interrupt the course of the veins and cause distortions that make it very difficult to compare the coleopterous venation with that of other orders.

In the first attempt to use the ontogenetic method of study cerambycid pupæ were used. These forms are very highly specialized and the tracheation no longer shows the course of venation development. Several workers have been thrown off by the theory of alternate convex and concave veins as applied to the Lepidoptera by Adolph (1880).

Burmeister (1842) first used the venation of the second pair of wings in systematic studies when he showed that the Carabidæ, Paussidæ, Dytiscidæ and Gyrinidæ possessed common characters of wing venation. After a study of the wing venation Otto Roger reached the conclusion that the Malacoderms were an ancient group from which all Coleoptera are derived except Adephaga which had previously branched off.

Ganglbauer (1899) recognized three types of wing venation in the Coleoptera, the first type of venation being characterized by having a large number of longitudinal veins running the length of the wing, and a number of cross-veins. Near the posterior extremity of M and Cu two mediocubital crossveins form a closed cell, the oblongum, which is constant in this first type of wing. This type of venation is limited to the caraboid families. The second type of venation or Staphylinoidean type is distinguished by the complete disappearance of crossveins and the basal portion of vein M. This type of venation is derived from the caraboid type by both Ganglbauer and Kolbe (1901). Lameere (1900) believed this second type

to have arisen from the Cantharoidean type of venation and consequently his arrangement of the families is influenced by this belief. The third type of venation or Cantharoidean type is defined by the disappearance of the basal portion of the medius and the curved hook-like connection which this vein makes with the cubitus. Vein R_2 also appears as a recurrent of R. It is this third type of venation which is characteristic of the families included in this study.

In 1915 Kuhne studied the tracheation of the pupæ of seven genera and disagrees with Comstocks (1899) as to the homology of the costo-radial group of trachea.

d'Orchymont (1921) made general studies of the adult wings of the Adephaga and Polyphaga for the purpose of working out a homologous system of the venation. Since d'Orchymont leaves the tracheation of the pupæ out of consideration Forbes (1922) believes that his results are only half correct and proposes another interpretation of the wing veins. Even Forbes' paper leaves the determination of the anal veins a difficult problem. In such forms as Brontes and Platisus the vein next Cu is independent of 2A and is considered to be 1A. In other forms such as Catogenus and Pediacius this same vein appears as a strong one branching from 2A. This condition may be explained on the grounds that 1A has changed its course so as to follow the course of 2A for a space and has again separated from 2A toward the margin. Such a condition is displayed by *Dermestes marmoratus* (Forbes, Fig. 36). *Dermestes marmoratus*, however, is not a transitional form between Brontes and Catagenus but is introduced here to show that such a condition occurs in the Coleoptera.

Martinov (1925) has suggested that the fourth anal of the Coleoptera is homologous with the jugum of the Mecoptera and has been included by the Coleoptera in the anal lobe to support this increase in wing expanse.

EROTYLIDÆ.

The venation of all the genera of the family Erotylidæ (Figs. 68, 73 and 75) is a uniform type of venation which does not vary among the genera as it does among the genera of other families. The Erotylid wing displays more of the primitive characters than any other form included in this study. The radial sector and radial recurrent are present, with a very short indication of the radio-medial crossvein. The first anal is also present with a cross vein to the vein Forbes labels $2A_2$. The presence of the wedge cell is also a primitive character. In

these lower forms the anal lobe is less definitely separated from the anal area than in the forms in which the first anal vein and wedge cell have disappeared. The fourth anal vein is also stronger in these forms. The broadly attached anal lobe and strong 4A may then be considered primitive.

MYCETOPHAGIDÆ.

In the Mycetophagidæ (Fig. 66 and 76) we have a general plan of venation similar to the Erotylidæ. *Mycetophagus punctatus*, Fig. 76, has the wedge cell present though vein $3A_1$ shows distinct signs of

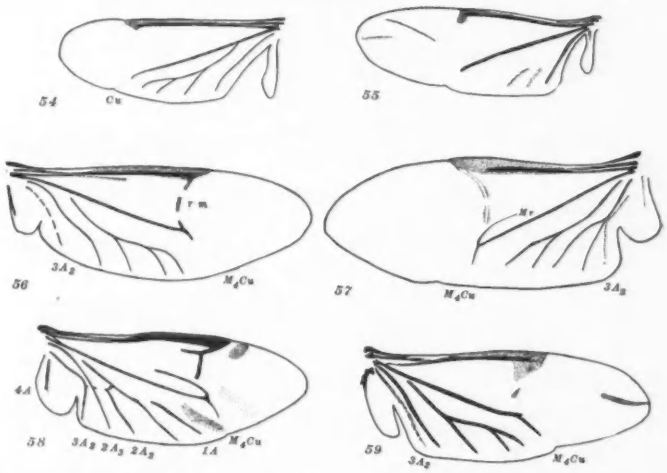

Fig. 54. *Oryzaephilus surinamensis* (L.).
Fig. 55. *Silvanus bidentatus* Fabr.
Fig. 56. *Telephanus velox* Hald.
Fig. 57. *Pediacus fuscus* Er.
Fig. 58. *Brontes dubius* Fabr.
Fig. 59. *Nausibius clavicornis* (Kug.).

disappearance. This vein has completely disappeared in *Mycetophagus flexuosus* (Fig. 66), and vein 1A is not attached to the cubitus as in *Mycetophagus punctatus* and the Erotylidæ. The radial sector, radial recurrent and radio-medial crossvein show a distinct relationship to that of the Erotylidæ, particularly when *Mycetophagus punctatus* (Fig. 76) is compared with *Triplax flavicollis* (Fig. 75). The Mycetophagidæ also show little tendency toward separation of the anal lobe from the anal region of the wing. The Mycetophagidæ and Erotylidæ are distinctly separated from the other forms by the fact that 1st A is more closely associated with Cu.

CUCUJIDÆ.

In the family Cucujidæ the venation of the various genera, though variable, shows some characters which are similar, or the modification may be explained as a reduction of the number of veins from a primitive type.

The venation of *Cucujus clavipes* (Fig. 60) probably represents the most primitive condition of the venation found in the family Cucujidæ. The reasons for giving it the primitive position are as follows. First, the radial region closely resembles the same area in the Erotylidæ. Second, the radio-medial cross-vein is still distinct in this form. Third, the anal lobe is broadly attached to the wing and the fourth anal vein is strongly developed.

In this genus the vein $3A_1$ fuses at the base with $3A_2$ and at about the middle of the vein crosses over to vein $2A_3$. The vein $2A_2$ is short and shows no basal connection with the other veins. Vein 1A branches from $2A_1$.

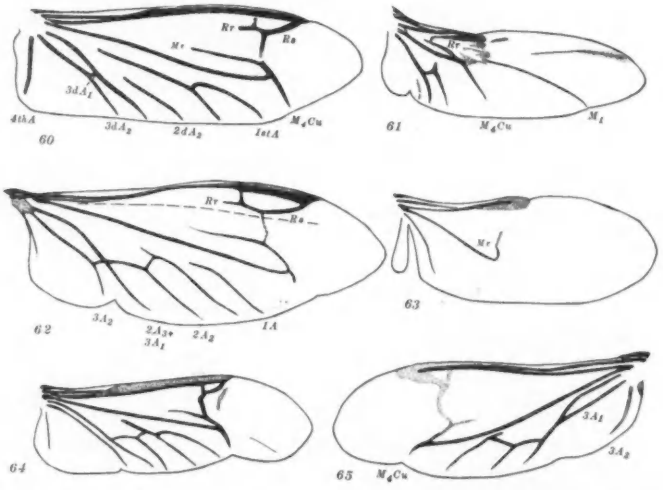

Fig. 60. *Cucujus clavipex* Fabr.
Fig. 61. *Glistrochilus obtusus* (Say).
Fig. 62. *Platisus* sp.
Fig. 63. *Laemophloeus liquidus* Csy.
Fig. 64. *Catogenus rufus* Fabr.
Fig. 65. *Prostomis mandibularis* Fabr.

Platisus (Fig. 62) differs from Cucujus in the following respects: 1A not branching from $2A_1$; $2A_2$ branching from $2A_3$ with a cross-vein between $2A_2$ and $2A_1$; radio-medial cross-vein obsolescent. On the other hand, it resembles Cucujus very closely in the radial area and the vein $3A_1$ is present as a cross-vein between $2A_3$ and $3A_2$.

In *Catogenus rufus* (Fig. 64) vein $2A_2$ branches from $2A_3$ and is connected to $2A_1$ by a cross-vein as in Platisus. The radial recurrent is absent but the radio-medial cross-vein is strong. Vein $3A_1$ is absent in this genus.

The venation of *Brontes dubius* (Fig. 58) resembles that of Cucujus in the radial area but in the anal region the venation is markedly divergent from that of Cucujus. The vein $3A_1$ is only represented by a

short stub from $3A_2$ and the distal part of $2A_2$ is separated from $2A_3$ but the cross-vein between $2A_2$ and $2A_1$ is intact. The vein 1A is unattached at the base as in Platisus.

In *Dendrophagus cygnaei* the anal area resembles that of Telephanus while the radial area is like that of Brontes.

In *Pediacius fuscus* (Fig. 57) the radial veins have become very much reduced so that nothing remains of the radial recurrent and radial sector. The disappearance of the cross-vein between $2A_1$ and $2A_2$ gives the pattern of the anal area a very different appearance from that of the other forms. Vein $3A_2$ is also obsolescent.

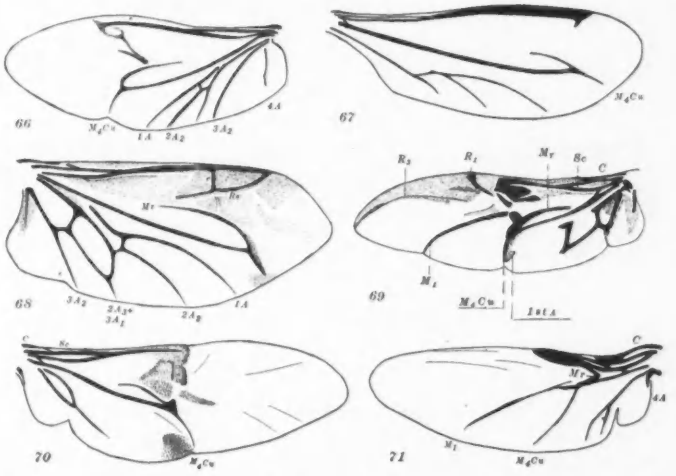

Fig. 66. *Mycetophagus flexuosus* Say.
Fig. 67. *Hemipeplus marginipennis* Lec.
Fig. 68. *Erotylus diviiris* Lec.
Fig. 69. *Hippodamia convergens* (Guer.).
Fig. 70. *Endomychus biguttatus* Say.
Fig. 71. *Carpophilus pallipennis* (Say).

The radial recurrent in *Prostomis mandibularis* (Fig. 65) has disappeared while the radial sector and radio-medial cross-vein show signs of breaking up and disappearing. In spite of this condition of disappearance the radial region still bears resemblances to the radial region in Catogenus. The anal veins have become so distorted that Prostomis is isolated from the other Cucujidæ. Vein $3A_2$ has crossed over and joined $2A_3$. The cross-vein from $2A_2$ to vein $2A_1$ is also present, but vein 1A is absent.

Hemipeplus marginpennis (Fig. 67) has a venation radically different from that of the other genera of the family Cucujidæ. The anal lobe has completely disappeared and the anal veins are reduced to three in number. Their position is so altered that it is impossible to determine the veins with certainty.

The venation of *Telephanus velox* (Fig. 56), *Nausibius clavicornis* (Fig. 59) and *Oryzaephilus surinamensis* (L) (Fig. 54) all resemble

each other rather closely. The radial recurrent and radial sector are absent in these forms with a slight thickening remaining at the end of the radius which indicates that these forms are descended from forms like Brontes. Indications of the radio-medial cross-vein are also present. In the anal area three branches are separated from 2A. The vein $3A_2$ shows signs of disappearing in Telephanus and Nausibius while it is completely absent in Oryzaephilus. The anal lobe gradually becomes more definitely separated from the anal area, too. In Oryzaephilus the fourth anal vein is absent.

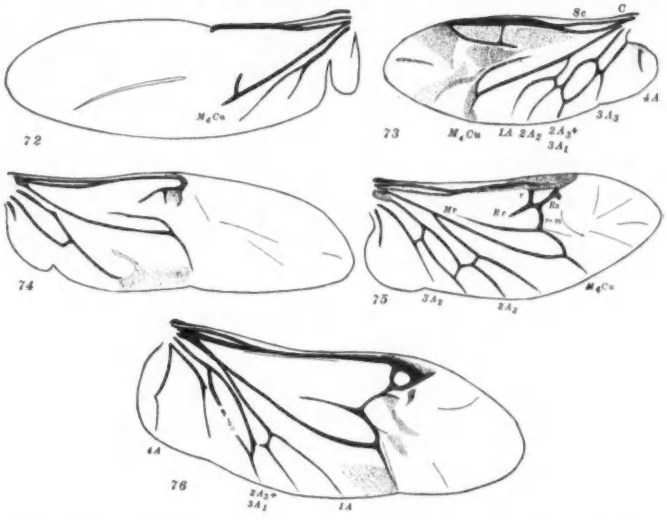

Fig. 72. *Phalachrus seriatus* Lec. Fig. 73. *Agithus genuinatus* Lec.
Fig. 74. *Aphorista vittata* (Fabr.). Fig. 75. *Triplax flavicollis* Lec.
Fig. 76. *Mycetophagus punctatus* Say.

In *Silvanus bidentatus* (Fig. 55) and *Cathartus opaculus* the veins of the anal area are very faintly indicated but the faint lines show these two genera to be related to the three genera just discussed. The shape of the anal lobe and the straight cubital vein are other points of similarity.

The five genera Telephanus, Nausibius, Oryzaephilus, Silvanus and Cathartus have a common type of venation and are distinct from the other members of the family Cucujidæ. The venation in this case indicates that these five genera may be separated as a distinct family on the following characters: Radius reduced to a single straight vein, with a small thickened area at the apex; Medial recurrent absent; $3A_2$ obsolescent; Anal lobe narrowly joined to the wing.

On the basis of wing venation *Laemophloeus liquidus* (Fig. 63) would be placed with Silvanus because of the very pronounced reduction of the venation and the distinct separation of the anal lobe from the remainder of the wing. It may be suggested here that since both Silvanus and Laemophloeus are small forms this reduction of venation may be due to the decrease in size. Then the similarity of venation in such form can not be used as a basis for determining relationships.

The venation of *Inopeplus reclusa* is also reduced to a minimum so that it resembles very closely the wing venation of Laemophloeus. The only difference between the two is that the medial-recurrent in Inopeplus is slightly longer than in Laemophloeus. This may be another case of convergence for the genitalia indicate that Laemophloeus and Inopeplus are not closely allied.

The venation of the family Nitidulidæ is represented by *Glistrochilus obtusus* (Fig. 61) for the veins of *Lobiopa setosa* and *Carpophilus pallipennis* vary only in slight details. The Nitidulidæ are peculiar in that

Fig. 77. *Monotoma producta* Lec.
Fig. 78. *Antherophagus ochraceus* Melsh.

the radial recurrent forms a deep loop toward the base of the wing which is unlike any of the other forms studied. The venation of the Histeridæ as illustrated by Forbes' figure of *Hister inequalis* agree with the Nitidulidæ in the loop-like form of the radial recurrent. Since this is the only detail in which the wings of the two families agree this must be considered as a convergence of characters. The presence of vein M_1 and the peculiar reduction of the anal veins is also characteristic of the Nitidulidæ.

In the Phalaridæ (Fig. 72) the wing is again characterized by a great reduction of the veins. The wing is long in proportion to the width which is rather remarkable in view of the lack of veins in the apical half of the wing. The members of this family are usually three millimeters or less in length. This small size of the beetle may again account for the extreme reduction of the wing veins.

The venation of the Cryptophagidæ as represented by *Antherophagus ochraceus* (Fig. 78) does not resemble any of the other families. The vein labelled M_1 is so labelled because it approximates the position of M_1 in *Carpophilus pallipennis* (Fig. 71) and because it is beyond the hinge fold. In none of the other forms does M_4 and Cu extend beyond the hinge fold. In *Cryptophagus croceus* this vein also appears to be a little nearer the costal border of the wing than in Antherophagus.

The presence of vein M_1 associates the Cryptophagidæ with the Nitidulidæ. In other respects, however, the venation resembles none of the other families.

The Monotomidæ (Fig. 77) have the venation reduced to such an extent that its affinities can not be determined. The radiomedial cross-vein is present as a short straight vein and shows no relationship to the Nitidulidæ.

The Endomychidæ are represented by *Endomychus bigutattus* (Fig. 70) and *Aphorista vittatus* (Fig. 74). In Aphorista the radial recurrent and radial sector are plainly visible with a short portion of the radiomedial cross-vein also present. The position of these veins is indicated in Endomychus by thickened areas. The anal veins are reduced to two veins at the base which converge to form a single vein toward the margin. The anal lobe is distinct, with a short fourth anal vein.

The venation of the Endomychidæ and Coccinellidæ is shown to be related when the venation of such forms as Scymnus is compared with the Endomychidæ, while in the more complex forms such as Hippodamia the relationship is not apparent. Another point which indicates the relationship of the two families is found in the folding of the wings. In both families the wings fold by a peculiar double fold at the hinge.

Hippodamia convergens (Fig. 69) is figured as typical of the Coccinellidæ. The venation, as represented by the Coccinellidæ and Endomychridæ are divergent from that of the other families of the order, and serves only to emphasize their isolated position. The veins represented are costa, subcosta, radius, media, cubitus, and anals. The costa is a weak vein extends for a short distance along the costal border of the wing, then fuses with the subcosta. The subcosta is a concave vein near the costa. Radius is a large vein forming the principal articulation with the body. The branching of the radius has been greatly reduced. Caudad of the hinge, vein R_1 is represented by a thin line. Vein R_3 is so labelled according to Forbes for two reasons, "first, that the apex of wing in low holometabelous insects is to be sought in the neighborhood of R_3 and second, on the plain connection of the stub identified as R_4 and R_5 across to the stem of R_3 in such forms as Tetracha." The basal portion of the median has disappeared, leaving the medial recurrent unattached at the base. "The branches of the medius are designated as M_1 and M_4 because they are the extreme members of the complex group (polyphaga) as shown by Hydrosus." M_4 toward the apex swings over and joins the cubitus. There remains but one vein supplied by the cubital trachea. Near the margin of the wing a small portion of what is called first anal is still present. The other veins of the anal area have not been satisfactorily worked out.

SUMMARY OF VENATION.

To summarize the evidence from the venation: we have the Erotylidæ and Mycetophagidæ closely related and representing the most primitive type of venation.

In the family Cucujidæ the venation of Cucujus, Platisus, Catogenus, Brontes and Dendrophagus resemble each other very closely in the formation of the radial region. The anal veins are rather variable but this is not carried to such an extent that would require their separation as distinct families, particularly in the case of Catogenus. Prostomis shows an obsolescent condition of the radial region, which resembles that of Catogenus very closely. But the arrangement of the anal veins is such that it is difficult to state definitely the relationship. In the case of Laemophloeus it is impossible to determine definitely the relationship because of the extreme reduction of the venation. Hemipeplus shows a very marked reduction of the radial area and of the anal veins. Telephanus, Nausibius, and Oryzaephilus show the same type of venation, which with Silvanus and Cathartus, form a group apparently derived from a form like Brontes. This group is distinct enough to warrant family rank.

The Nitidulidæ possess a peculiar venation which is unrelated to any of the other forms studied.

In the Phalacridæ the venation is very reduced. In the anal area there are two veins left which slightly resemble the Nitidulid venation in this area.

The Cryptophagidæ according to the body characters and the genitalia should be placed close to the Erotylidæ, but the venation of the wings fail to show any relation to the other families.

The reduction of the venation of the Monotomidæ is so great that the relationship to other families is obscure.

The families Endomychidæ and Coccinellidæ are shown to be related both by the venation and the folding of the wings. This type of venation and folding is of such a distinct nature that the two families should be placed in a separate series.

CONCLUSIONS.

When a comparison of the evidence from the wing venation and the genitalia is made, the Mycetophagidæ are shown to be the most primitive of the families studied. Both the wing veins and the aedeagus indicate that the family is related to the Byrrhidæ and should be placed in the Byrrhoid series rather than with the Cucujoidea.

The genitalia, wing venation and body characters furnish no basis for a division of the Cucujidæ into the four families as suggested by Böving. All of the evidence does indicate, however, that the family Silvanidæ as proposed by Böving may be accepted. The genus Telephanus is closely related to Brontes, thus the Silvanidæ are related to the Cucujidæ.

Handlirsch in arranging the fossil Coleoptera suggests that the Cucujidæ arose from a hypothetical Protophytophaga as early as the Upper Triasic, while the other families usually included in the series Clavicornia arose during the Jurassic and Cretaceous. He separates the Cucujidæ as a distinct series. The fact that the wing venation of the Cucujidæ and Silvanidæ is not related to other families supports Handlirsch's view. The aedoeagus also furnished evidence which indicate that the Cucujidæ and Silvanidæ should be recognized as independent. The aedoeagus of the Cucujidæ ranges from a very simple type in Hemipeplus to a very complex type in Catogenus. This diversity of structure leads to the conclusion that the family is a very old one from which many intermediate forms have disappeared. The Cucujidæ and Silvanidæ are separated from the Mycetophagidæ by the fact that the tegmen forms a complete ring around the median lobe, and are distinguished from the other families studied by the fact that the tegmen is ventrad of the aedeagus. Such considerations, I believe, justify separating the Cucujidæ and Silvanidæ from the other families studied. The series Cucujoidea would then include only the families Silvanidæ and Cucujidæ.

According to the genitalia the Nitidulidæ, Monotomidæ and Phalacridæ constitute a homogeneous group having the tegmen redued to a single large sclerite on the dorsal aspect of the aedeagus. On the basis of the genitalia the Phalacridæ should be placed near the Nitidulidæ instead of between the Endomychidæ and Coccinellidæ, which is the usual arrangement. Since the Silvanidæ and Cucujidæ are considered as a distinct series the three families Nitidulidæ, Monotomidæ, and Phalacridæ will constitute a new series for which I propose the name Nitiduloidea. The wing venation of this series is so reduced that it is of little assistance in determining the relationship of these families.

The Erotylidæ, Cryptophagidæ, Endomychidæ, and Coccinellidæ are placed together to form another series to which I

give the name Erotyloidea. This group is characterized by having the tegmen composed of a basal piece enclosing the median lobe, and the lateral lobes attached to the sides or apex of the basal piece. The aedeagus also rests on its side when retracted into the abdomen and is arranged so that it turns through an angle of ninety degrees when extruded. The wing venation of the Erotylidæ resembles that of the Mycetophagidæ more closely than that of either of the other three families, but the evidence from the genitalia indicates that the Erotylidæ should be placed with the Crytophagidæ, Endomychidæ, and Coccinellidæ. The venation of the Endomychidæ and Coccinellidæ is very similar. The method of folding the wings in these last two families is also exactly the same.

ACKNOWLEDGMENTS.

For the loan of material I am indebted to Professor Nathan Banks of the Museum of Comparative Zoology, who generously allowed me to take duplicates from the Museum collection for dissection. Mr. A. J. Mutchler of the American Museum also loaned specimens of Cathartus and Silvanus for comparison. The work was carried on under the direction of Professor W. M. Wheeler and Professor C. T. Brues, and to both I am greatly indebted for valuable suggestions and helpful advice.

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CONTRIBUTIONS TO THE LIFE HISTORY OF THE ICERYINE COCCIDS, WITH SPECIAL REFERENCE TO PARTHENOGENESIS AND HERMAPHRODITISM.

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INTRODUCTION.

The coccid tribe Iceryini as recently defined by Morrison ('28, '30) comprises the genus Icerya and five other genera closely allied to it. Of this group the life cycle of only *Icerya purchasi*, the cottony cushion scale, is at all adequately known. This species presents so many unique features, especially relative to its reproductive processes, that any contributions to our knowledge of nearly related species holds an especial interest. The present study presents new data on four other members of this group—data derived from field study, from the cytological investigation of material preserved in the field, and from breeding experiments, made during two extended trips in Central America in the years 1928 and 1929. The species

*Sarah Berliner Research Fellow, 1929.

studied are *Icerya montserratensis* Riley and Howard and *Icerya littoralis* Cockerell, two forms, which, with *Icerya purchasi* Maskell, represent three different sections of the genus Icerya, *Crypticerya rosæ* Riley and Howard, and *Echinicerya anomola* Morrison, a new genus and species discovered during my 1928 trip in Guatemala and recently described by Dr. H. Morrison of the United States Bureau of Entomology. To Dr. Morrison I am also indebted for the identification of all the other types herein reported. Grateful acknowledgment is also made to the donor of the Sarah Berliner Research Fellowship, and to the American Association of University Women awarding it, whose support made the field work of 1929 possible. The field work of 1928 was done in collaboration with Professor Franz Schrader of Bryn Mawr College.

A preliminary review of the life cycle and reproductive processes of *Icerya purchasi* will first be presented. For, although the general features of the life history of this species have been known since the pioneer studies of Riley and Howard ('86, '90), it is only recently that a correct interpretation of its reproductive processes has been reached. The present review is intended therefore to bring together in one report the somewhat scattered material now available on this type, and thus to facilitate comparisons with the other Iceryines studied.

Icerya purchasi Maskell.

DISTRIBUTION AND HOSTS.

Morrison gives the present occurrence of *Icerya purchasi* as world wide, Australia having been the probable center of its distribution. Aside from greenhouse infections in many cities of the United States, I have encountered it living outdoors in many localities in California, in Louisiana, and in Guatemala, Central America. In food habit *Icerya purchasi* is truly polyphagous. The various species of Acacia, Mimosa, citrous trees, and roses seem especially favorable hosts. But inasmuch as Ptospormum, cypress, pine, grasses, elm, ivy, oxalis, and palms have all been observed as hosts, it is clear that there is no obligatory relation between the insect and any certain group of host plants.

LIFE CYCLE.

The general structure and appearance of the different instars of *Icerya purchasi* are too familiar to need review here. The life cycle occupies, according to Kuwana ('22b), approximately four months under favorable conditions in Japan. Thus three generations are possible there annually. Leonardi ('20) reports three generations annually to be characteristic for the species in Italy; and under greenhouse conditions in Pennsylvania I find the same to hold true. Unfavorable environmental conditions may increase the duration of each or all instars, so that as few as one generation may be obtained in a given year. Kuwana gives the average life cycle as follows for females:

Incubation period	21 to 27 days
First instar	14 to 21 days
Second instar	14 to 21 days
Third instar	21 to 50 days

I can add that the fourth or adult stage in the female usually comprises from two to three months. For males the incubation and first and second instar periods are the same as in the females. Third instar males, however, immediately after the second molt, undergo a short period of restless wandering and then hide away in dead leaves or bark crevices and secrete the "cocoon" of loose wax in which the third and fourth instars are passed. This cocoon period comprises 17 to 21 days. The adult male or fifth instar has a maximum life of eight days after emergence from the cocoon, I can substantiate these data of Kuwana's in every respect from my own breeding experiments on this species.

The mating habits of *Icerya purchasi* have been described in detail by Shinji ('17) and myself ('25). Copulation occurs in nature usually during the late afternoon. The males evince a weak mating instinct as compared with the females. The latter react at once to the near approach of the males by raising the posterior tip of the abdomen. When copulation occurs the male mounts the up-tilted body of the female and clings to its posterior margin. The abdomen of the male is then bent under that of the female, and the penis inserted into the genital aperture of the female. The female retains the position with abdomen upturned during copulation thus holding the male up from the surface of the host plant. Copulation lasts from two

to five minutes. Females will mate frequently and with many different males; the males rarely mate more than once, and it is not unusual for a male entirely to ignore the presence of females even though the latter may be reacting vigorously at the time.

The females are capable of copulation immediately after the third molt, and for a variable number of days thereafter, the period being terminated by the growth of the wax egg-sac which soon covers the genital aperture. All fourth instar females whether fertilized by males or not produce these characteristic egg-sacs. Eggs are deposited continuously during a period of about two weeks, the first young hatching in three to four weeks after the beginning of egg-sac formation. Due to the very long adult life of the females the generations of *I. purchasi* are seen to overlap; but counting from the time of the egg laying in one generation to the egg laying in the next, it will be seen that approximately ten to fourteen weeks are required to complete one cycle.

There are several possible causes for the wide variation in duration of the different periods of the life cycle as computed above. Any instar may be lengthened by various unfavorable environmental conditions such as a sudden drop in temperature, the cessation of active growth of the host plant, or too moist an atmosphere. The last factor favors the growth of molds in the sweet excreta of the insects. Some of these molds actually infect the bodies of the insects themselves and, although seldom fatal, slow up development decidedly. Again the incubation period, as Kuwana terms the time between egg laying and hatching, is extremely variable due to the fact, common among coccids, that the eggs are retained in the body of the mother until widely different degrees of development are attained.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM

All observers of *I. purchasi* agree in reporting a very unbalanced sex ratio, with the females preponderating largely over the males. This scarcity of males, together with his embryological studies on the species, early led Pierantoni ('10) to conclude that parthenogenesis was the usual mode of reproduction. He therefore isolated young female nymphs from males and discovered that indeed egg sac formation, egg laying, and the production of normal young occurred in the

complete absence of males. Later Kuwana ('22) also reported parthenogenesis for this species, after having raised several generations in the complete absence of males. That the rare males do mate with the females in nature has been repeatedly observed as noted above (Martelli (Pierantoni '10), Shinji ('17), Kuwana ('22), and Hughes-Schrader ('25)). Altogether the above evidence would ordinarily be considered an adequate demonstration of the occurrence of a facultative parthenogenesis. In this case however the situation was further complicated by the interesting observation of Pierantoni ('14a) that certain of the nymphs showed traces of hermaphroditism in their gonad structure. Pierantoni believed this hermaphroditic phase to be a transient one and the hermaphroditic nymphs to transform into normal males.

My own work (Hughes-Schrader '25, '26, '27) has demonstrated that all of the so-called females of *Icerya purchasi* are in reality hermaphrodites capable of the self-fertilization of their own eggs by their own sperm. Copulation may indeed occur between these hermaphrodites and the occasional males, but it is in no wise necessary for reproduction. Cytological study shows that the hermaphrodites are always diploid in chromosome constitution while the males are haploid. The diploid chromosome number is four, and the haploid two; in both sexes the cytological conditions are exceptionally clear and convincing. The hermaphroditic gonad is basically an ovary. During development the right and left gonads meet and fuse anteriorly dorsal to the gut thus forming a horseshoe shaped structure whose posterior ends terminate in short ducts. The fusion of these ducts posteriorly forms a heavy walled glandular vagina which leads to the external genital aperture. At the point of junction of the ducts there may occur a small thin walled blind diverticulum, the spermatheca, as described by Johnston ('12); but this may be entirely absent as stated in my 1925 study. Since that time I also have found it present in certain specimens, and believe it to be of rather general although variable occurrence. In the majority of coccids the ovaries are hollow structures with the eggs forming in pouches or ovarioles from their walls. In *Icerya purchasi* however the hermaphroditic gonad is solid during the early instars. In the first instar certain of the centrally lying cells become reduced to the haploid condition, and these

haploid cells, proliferating rapidly, come to form a solid central core in the gonad. The outer cells remain diploid and from them the ovarioles with their oocytes and nurse cells, the follicular and interstitial tissue are all derived. The haploid cells give rise to sperm. As the sperm mature they become twisted into tight bundles; the bundles are coiled and come to lie freely in the central cavity of the gonad. The gonad is thus actually hollowed out by the process of sperm formation. From the outer walls of the gonad meanwhile normal ovarioles are developing in which the eggs come to maturity. All eggs undergo two normal maturation divisions, in which the chromosomes are reduced to the haploid condition. If these eggs are fertilized by sperm, diploid embryos are produced which always give rise to hermaphrodites. If the eggs remain unfertilized, they develop parthenogenetically into haploid males. Fertilization of the eggs of the hermaphrodite by its own sperm has been demonstrated cytologically in a large series of hermaphrodites which were held in complete isolation from males.

Since the hermaphrodite produces ripe sperm in large numbers before the period when copulation with a male is possible, one cannot determine with certainty whether the sperm of the males are also potent. Copulation does not affect the parthenogenetic production of males; extended breeding experiments have shown that males are produced in varying numbers indifferently by both hermaphrodites which have mated with males and those which have been completely isolated from males. Thus from 31 hermaphrodites which had mated with males 2,548 hermaphrodites and 39 males were produced; while 10 hermaphrodites isolated from males gave rise to 1,616 hermaphrodites and 5 males.

There is no evidence that this condition,—of functional hermaphroditism coupled with facultative parthenogenesis of haploid males—is restricted to an isolated strain or sub-species of *Icerya purchasi*. On the contrary, I have examined material from Italy, from Boston, Massachusetts, New York City, New York, Philadelphia, Pennsylvania, Berkeley, California, and from Antigua, Guatemala, and in every case have found the same conditions. It is certainly probable that this condition is characteristic for the species as a whole. With reference to this point an examination of *Icerya purchasi* as it occurs in Australia, its supposedly original center of distribution, would be of extreme interest.

The general anatomy of the hermaphrodites, their close correspondence in structure and habits with the true females of other coccids, together with their retention of the mating instinct of females, all indicate that the *I. purchasi* hermaphrodites are modified females. Indeed the very existence of normal males is evidence of the primitively bisexual condition of the species. That the hermaphrodites are homogametic for sex as are the females of other coccids (see Schrader's work on Gossyparia and many species of Pseudococcus and Thomsen's studies on several Lecanium species)—is shown by the fact that all their eggs when self-fertilized give rise again to the hermaphrodite type. The establishment of functional hermaphroditism as the regular and successful mode of reproduction in *I. purchasi*, may thus be regarded as definitely a derived and not a primitive character. The facultative parthenogenetic production of haploid males on the other hand may be a primitive character surviving, or, as the small and variable number of males produced may indicate, dying out in consequence of the establishment of the hermaphroditic habit; or, it may represent another secondary development paralleling that of hermaphroditism. Such considerations as these, together with the further questions whether these unique sexual and reproductive conditions represent an isolated development in a single species or are typical for a larger group of forms,—whether any transitional or related phenomena may exist in related species,—gave the point of departure for the following studies on closely related forms.

Icerya montserratensis Riley and Howard.

DISTRIBUTION AND HOSTS.

Icerya montserratensis has been reported from the West Indies and from Mexico, on a wide range of host plants including unidentified species of Chrysophyllum, Clusia, Acacia, orange, banana, avocado, and palm. My collections were made at Belize, British Honduras, on various cultivated roses and palms, and at Stann Creek, British Honduras, on grapefruit trees. Although so unrestricted in choice of host plant, the insects thrive better on certain forms than on others. In my experience rose offers the best medium, with palms second. Reduced size and very slow development characterize broods grown on any of the citrous fruit trees.

As in *Icerya purchasi* the young nymphs attach themselves to the under side of the leaves of the host plant, sinking their proboscides into the veins of the leaves. Older nymphs and adults attach themselves to the twigs and smaller branches. Recognition of *I. montserratensis* in the field is easy, due to the large fluted egg sac of the adult female which turns up at the distal end instead of downward as in *I. purchasi*. The marginal wax tufts on each side of the anus are prolonged into graceful and often curling strands sometimes reaching a length twice that of the body of the female. These strands hanging posteriorly and ventrally over the egg-sac form a striking character for naked-eye recognition. The anterior median wax tuft is also tremendously developed (about half the length of the body) and projects forward stiffly.

NUMBER OF GENERATIONS ANNUALLY.

During the dry season from three to four months are required for the completion of a single generation. Since all instars are present on the host plants from January until May, it is probable that breeding goes on more or less continuously throughout the year. If this is the case three generations a year are possible as in *I. purchasi*. Lowering of the temperature will however retard development greatly in all instars, and it is quite possible that the number of generations annually varies from one to a maximum of three depending on weather and food conditions.

DURATION OF THE SUCCESSIVE INSTARS.

Under favorable growing conditions the first larval instar in both sexes occupies from 19 to 25 days; the second instar from 17 to 24 days in the case of males, and 19 to 24 days in the case of females. Immediately after the second molt the behavior of the two sexes differs. Male larvæ of the third instar become restless and migrate from the host plant seeking a dark place in which to spin their cocoons. They may be easily distinguished from the females at this time by their longer slenderer abdomen and the almost complete absence of wax. One or two days may be spent in active wandering back and forth, after which the male larvæ settle down in the loose dry surface earth or in dead leaves and bark crevices, and secrete their cocoons of very loose and fluffy wax. The whole

third and fourth instars are spent in the cocoon—an average interval of 26 days elapsing between the second molt and the emergence of the adult males. The time of the occurrence of the third and fourth molts was determined in a few cases only. Cocoons opened to obtain cytological material showed that the third instar has an average duration of 9 to 10 days. Similarly, in a few cocoons opened on the 23rd day of the cocoon period, one male was found which had already made its last molt. It is probable therefore that from one to several days of the cocoon period belong to the adult stage. After emerging from their cocoons the adult males live for 3 to 8 days.

Female nymphs continue to feed quietly on the host plant during the third and fourth instars. In four individuals timed the duration of the third instar was from 20 to 29 days. Immediately after the third and, for the females, the final molt, the females are ready for fertilization. The long duration of the third instar in the female as compared with male nymphs quite equalizes the fact that the females have one less instar than the males, and brings the time of sexual maturity in the two sexes simultaneously. Thus the total time required for the larvæ to reach sexual maturity from the time of the hatching of the eggs is 57 to 78 days in the case of males and 56 to 78 days in the case of females. The adult life (fourth instar) of the female, whether fertilized or not, is very much longer than that of the male—always comprising one month and often six to nine weeks.

MATING, EGG-SAC FORMATION, AND DEPOSITION OF EGGS.

As in *I. purchasi* the mating instinct is much stronger in females than in males. Practically all females for two or five days after their third molt will react by lifting the tip of the abdomen to the presence of males, if the latter come within a distance of half an inch or less. The males on the other hand are very capricious—occasionally reacting immediately to the presence of females of suitable age, but as often showing no reaction whatever and even climbing over the upraised bodies of the females to attain a sheltered position on the under side of a leaf. When a mating does occur there is no preliminary courtship other than an occasional stroking of the body of the female with a foreleg of the male. Copulation occurs as in *I. purchasi;* the male clings to the posterior tip of the abdomen

of the female and slips his abdomen under hers to insert the penis into the genital aperture. Due to the small size of the male he is usually held up free from the host plant by the up-raised abdomen of the female during the copulation, which lasts from three to seven and a half minutes. A single female often mates more than once and with many males. A single male seldom mates more than once in a given day—although it is probably unfair to judge their behavior in nature from that of specimens kept in vials and only liberated for short periods for experimental purposes, as were those on which these observations are based. One male used in the breeding experiments described below gave five matings on consecutive days but it was more usual to obtain none, one or two from each specimen.

Within one or two days after copulation the ventral side of the abdomen of the female becomes covered with wax, thus preventing further mating. However the females will still to the approach of males for many days after this time, react although the males invariably ignore such advances. The characteristic egg-sac, long, fluted, gradually turning up at the posterior end, begins to form within a few days after fertilization, and slowly increases in size during the period of egg laying. The first eggs are deposited as soon as the first section of the egg-sac is complete, often as soon as four or five days after fertilization, and eggs continue to be deposited thereafter for many days. From the time of fertilization to the emergence of the first young from the hatching eggs 33 to 35 days elapse. As was pointed out for *I. purchasi* this period does not correspond necessarily to the whole embryonic period since the eggs are at very different stages of development when they are deposited. One entire life cycle, from the hatching of the eggs in one generation to the hatching of the eggs of the next generation, is seen to occupy from 90 to 113 days. These records are based on several broods growing on rose trees in the dry season and probably represent maximum speed of development. Some idea of the variation in the length of the life cycle under less favorable conditions may be gained from the following observation. From one brood whose total developmental period on rose was just three months, some young were transferred early in their first instar to a grapefruit tree. The host plant was over-crowded, molds developed in the excreta of the insects, and in general the conditions were

very unfavorable. These nymphs were still in their second instar when that part of the parental brood raised on the rose tree had reached the adult stage. This would indicate a possible retardation of the developmental period to double that required under favorable circumstances.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM.

Virgin females, kept in isolation from males, behave at first quite as do those which have mated with males. The egg-sac, although its formation is delayed until the fifth to seventh day after the final molt of the female, eventually attains as large a size as in fertilized females. The number of eggs laid is approximately the same. Thus far conditions parallel those in *I. purchasi* closely. In marked contrast to *I. purchasi*, however, the young produced by unfertilized females of *I. montserratensis* are always male in sex. This conclusion is based on breeding experiments in which virgin females were kept under gauze bags and thus isolated from males. Records of the separate broods were not kept, other than to check up daily during the crucial instars for the possible appearance of females among the offspring. Some 200 males and not one female were produced by three such isolated females. Broods from fertilized females, on the other hand, always comprised both males and females. Exact records were not kept of the number and sex of the offspring of each fertilized female, owing to inadequate facilities for growing and isolating the broods, but a mass culture from several fertilized females on one rose tree produced some 200 young, among which some ninety males were recorded. Meager as they are, these breeding experiments indicate fairly clearly that fertilization is necessary for the production of female offspring, while males may be produced from virgin females. Such experimental breeding is however inadequate for an analysis of the reproductive processes involved, since it provides no distinction between the effects of parthenogenesis and hermaphroditism. Accordingly a cytological study was made of both fertilized and non-fertilized females and of the eggs of each type in all stages of their development. A detailed account of the purely cytological features of gametogenesis, fertilization, and development will be published elsewhere. It will suffice here to summarize only those results bearing directly on the life history.

In the first place there is no trace of hermaphroditism in any instar of either sex. The gonad of the female is a typical ovary. In general form it corresponds to the hermaphroditic gonad as described for *Icerya purchasi*. The right and left ovaries fuse anteriorly dorsal to the gut thus giving the organ a circular shape. This fusion occurs early in the second instar. Posteriorly each ovary terminates in a duct which unites with its fellow from the other ovary to form a thick walled glandular vagina. At the point of junction of the two ducts a small and very delicate thin walled spermatheca has its origin. As in most coccids the cavities of vagina and ducts are continuous with the central cavity of the ovary. The eggs are produced in typical ovarioles on the wall of the ovary and pass into its central cavity when mature. The ovaries are hollow from a very early period in their development and there is never a trace of the development of spermatogenous tissue in them such as is found in *I. purchasi*. The constant presence of a spermatheca, a character subject to considerable individual variation in *I. purchasi*, and the comparatively greater length of the sterile ducts connecting ovaries and vagina, further distinguish the *I. monserratensis* from the *I. purchasi* gonad. The anterior fusion of the right and left gonads is shown in *montserratensis* in common with all the Margarodidæ thus far examined; it may well prove to be a constant anatomical character for the whole family. Schrader ('30) has recently described this same general type of ovary as being characteristic for *Protortonia primitiva*. In Protortonia, however, the ducts are even shorter than in *I. purchasi* and the egg bearing region of the ovary correspondingly longer. The spermatheca is also relatively better developed than in any of the Iceryines studied.

The diploid chromosome number in *I. montserratensis* is four. All eggs undergo two perfectly normal maturation divisions by which the chromosome number is reduced from four to two. If the eggs are fertilized and the diploid condition thus restored they develop into females. All unfertilized eggs develop into males which thus come to be characterized by the haploid chromosome number.

These findings confirm and explain the results of the breeding experiments. Isolated females naturally produce nothing but males since all their eggs undergo reduction and develop without fertilization or other means of restoring the diploid chromosome

condition as haploid male individuals. Fertilized females, on the other hand, produce mixed broods, those eggs which are fertilized by sperm developing into females and those which escape fertilization developing parthenogenetically into males. In the light of this cytological mechanism the number of males produced by fertilized females seems surprisingly high. A discussion of the possible causes for this phenomenon will be reserved until the section dealing with *Icerya littoralis*, since my breeding data for the latter species are more complete relative to this particular point.

Icerya littoralis Cockerell.

DISTRIBUTION AND HOSTS.

Icerya littoralis was collected and studied in the vicinity of Salamà, Baja Vera Pas, Guatemala, during the spring of 1929. The usual host plant was a common species of acacia, locally called subin, although other species of acacia, palms, and even certain grasses near a heavy infection, were also observed to be occasional hosts. Breeding probably continues more or less regularly throughout the year, since all stages from first instars to adults were present on the host plants at all times during February, March, April, and May. As in *I. monserratensis*, a dry season brood may be completed in from three to four months, thus making three generations a year at least theoretically possible.

In the field, *I. littoralis* has a very characteristic appearance. It resembles *I. purchasi* closely in body form, and in the down turned fluted egg-sac, but may be readily distinguished in naked-eye examination by its smaller size, the absence of the black hairs of *purchasi*, and by the color of the skin which is a bright rose red in contrast to the brown red of *purchasi*. The adult female is closely covered with wax dorsally; the marginal wax tufts are very short in front and increase in size by uniform degrees from anterior to posterior, thus making a fringe of wax tufts which hang down over the completed egg-sac. The longest of these tufts is seldom as long as the body of the female; this, and their even gradation in length, make confusion with *I. montserratensis* impossible.

LIFE CYCLE.

In general habits this species approximates *I. monserratensis* so closely that only a brief summary of my notes relative to its life cycle will be submitted. The duration of the different instars is as follows. In the case of male nymphs, the first instar occupies on an average 20 days, the second 15, and the third and fourth together or cocoon period, 21 to 25 days; giving a total of 57 to 60 days from hatching to sexual maturity. Female larvæ spend 20 to 25 days in the first instar, 16 to 19 in the second, and 22 to 30 in the third—a total of 58 to 74 days from hatching to sexual maturity.

Females are capable of fertilization immediately after the third molt and for the five or six days immediately ensuing. Mating habits are identical with those of *I. montserratensis*. The duration of copulation is markedly shorter, varying from two to four minutes in the sixteen cases observed. Both males and females may copulate more than once either with the same or different individuals. One male was seen to mate three times, on successive days—and one female to mate four times in rapid succession with four different males. The mating period of the female is terminated by the growth of the egg-sac which soon covers the genital aperture.

The secretion of the egg-sac is begun on the fifth to seventh day of the fourth instar irrespective of whether the female has been fertilized or not. The first eggs are deposited as soon as the first short section of the sac is completed. Continued slow deposition of eggs and the gradual posterior extension of the egg-sac go on for two to three weeks. The first larvæ hatch in from 31 to 38 days after the egg-sac has been started, and first instar larvæ continue to emerge thereafter for two or three weeks more. Summating these periods it will be seen that the duration of the life cycle, from the hatching of the eggs of one generation to the hatching of the eggs of the next, is 94 to 119 days. Again it should be emphasized that these figures apply to dry season broods under favorable conditions of growth.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM.

The sex ratio in *I. littoralis*, determined from a random collection of larvæ preserved for cytological study, was 30 males to 14 females, a ratio sufficiently one-sided to suggest

unusual reproductive behavior. Breeding experiments demonstrated conditions paralleling those in *I. montserratensis*. Virgin females form egg-sacs and lay eggs, as do females fertilized by males, but all eggs from virgin females give rise to male offspring exclusively. One such virgin female, reared in careful isolation from males, produced 24 males and no females. (This brood was greatly reduced by predacious mites before sex determination was possible.) Two other virgin females, whose offspring were not separated upon the host plant, produced 102 offspring, all of which were males. In no case did any virgin female give rise to female offspring. Fertilized females, on the other hand, produce both male and female young. Three females, each of which had copulated at least once, produced the following broods: 29 males to 51 females, 23 males to 20 females, and 43 males to 49 females. All of these broods are smaller than is normal in nature due to the difficulties in rearing complete broods on small plants under observation. The larvæ reared represent a random selection from the eggs in a given egg sac.

As was suggested for *I. montserratensis* the percentage of eggs that fail of fertilization in females that are known to have mated with potent males is surprisingly large. In the breeding experiments listed above the males are seen to comprise 44% of the brood of fertilized females. One factor in keeping the number of males high may well be insufficiency of sperm. It seems quite probable that the number of sperm received by the female at a single mating should be insufficient for the fertilization of the large number of eggs often produced. The conditions in *Icerya purchasi* lend support to this hypothesis. In *I. purchasi* sperm are produced by the hermaphrodites in tremendous numbers--(at the end of the male phase the ducts of the hermaphroditic organ are filled with sperm and sperm bundles from anterior to posterior end); and the number of males produced is correspondingly small. A second possibility is that some eggs may start their parthenogenetic development before copulation. I have had no opportunity to check this with precision cytologically. In the few females examined cytologically just before egg-sac formation no developing eggs or embryos were encountered, but I consider the evidence insufficient to eliminate the possibility that comparatively late copulation may be an occasional factor making toward a high

percentage of male progeny. The very small number of males produced by I. purchasi may be cited in indirect support of this suggestion also. There is no possibility in this case that the eggs start development before the arrival of the sperm since the hermaphroditic gonad is markedly protandrous and the sperm mature long before the eggs. It is clear that other factors than those just suggested must be operative in the case of *I. purchasi* to account for the production of any males at all by that species. It has been suggested (Schrader and Hughes-Schrader '26) that a late opening of the peduncular ducts connecting the egg follicle or ovariole with the main duct of the gonad might act as a bar to fertilization until after parthenogenetic development was under way. Such undetermined factors may well operate also in the cases of *I. montserratensis* and *I. littoralis*. Some further analysis of the factors involved in this question could be obtained by breeding experiments designed to determine the effect of the age of the female, and of repeated matings, on the sex ratio.

Cytological conditions in *I. littoralis* also parallel those of *I. montserratensis* with surprising closeness. There is never any trace of hermaphroditism in any instar. The ovary of the female is of the same structural type as *I. montserratensis*. The chromosomes are identical with those of *I. montserratensis* in number, size, shape, and behavior. All eggs undergo reduction. If fertilized these eggs give rise to females characterized by the diploid chromosome number; if they are unfertilized they develop parthenogenetically into haploid males.

Considering the breeding and cytological evidence together it is clear that *Icerya littoralis* is a normally bisexual species such as *I. montserratensis* without any trace of the hermaphroditic habit. In common with both *I. purchasi* and *I. montserratensis*, however, it shows the facultative parthenogenetic production of haploid males. Fertilization of the eggs of the female by the sperm of these males is necessary for the production of female offspring.

Echinicerya anomola Morrison.

A single and very limited occurrence of this interesting new Iceryine was found on one tree, an unidentified species of Acacia, in the vicinity of Quirigua, Guatemala, in March 1928 and again in the same region in 1929. On both occasions all

nymphal instars were present, suggesting more or less continuous breeding throughout the year as in Icerya. The adult females are very striking in appearance, making recognition in the field easy. The four anterior median dorsal wax tufts are prolonged into stiff spines of which the fourth or most posterior is longest. The females form no egg-sacs whatsoever; the eggs are deposited under the body of the parent which becomes increasingly concave ventrally as egg laying goes on.

The ovary of the female shows the anterior fusion of right and left halves characteristic of all other margarodids reported so far. Certain variations are characteristic; the ducts connecting the ovaries with the vagina are very long in comparison with the Icerya condition, thus restricting the ovaries proper, or actual egg bearing portion of the gonad to the anterior half of the organ. The spermatheca is constantly present and attains a development comparable to that in *I. montserratensis* or *I. littoralis*.

There is no trace of hermaphroditism in any instar in either sex. In cytological detail there is surprising correspondence with the *Icerya montserratensis* and *I. littoralis* condition. Females of all instars are diploid, with a chromosome number of four; males are always haploid, with the reduced chromosome garniture of two. All the eggs of the female undergo reduction. If fertilized the diploid number is restored and development into a female results. Unfertilized eggs are also capable of development, and as in the other species described, they never restore the diploid chromosomes but develop into haploid males. In the ovaries of fertilized females (so determined by the presence of sperm bundles and loose sperm in their ovarian ducts) both haploid and diploid embryos are found. In unfertilized females, (those showing no sperm within ovaries or ducts) only haploid embryos are found. Although no breeding experiments were possible with this species, the cytological evidence just given, together with the close similarity to *I. montserratensis* and *I. littoralis*, indicate pretty clearly that the reproductive processes involved are the same as in the two last-named species.

Crypticerya rosæ Cockerell.

A very slight infection of *Crypticerya rosæ* was found in February, 1928, near Orange Walk, British Honduras, on a species of Inga locally termed the Guama tree. The adult

female resembles Icerya in body form but is more convex and almost completely devoid of wax dorsally. As in Echinicerya no egg-sac whatever is made, and the eggs are laid under the body of the female, a few at a time, probably over quite a period of time. The only adult female in my collection was neatly covered with an ant carton. The prevalence of certain coccinellid beetle larvæ which prey upon these large soft bodied coccids suggested that only females so protected had survived in this *vicinity*.

No breeding work was undertaken on this species and the small number of individuals found were all preserved for cytological study. This material includes one adult female whose huge ovary contains a large number of embryos in practically all stages of development from the maturation of the egg to late embryos almost ready to hatch—one second instar nymph, and eight larvæ of the first instar. The female shows no trace of hermaphroditism. The ovary is of the type described in Icerya and Echinicerya, with a striking increase in the relative length of the ducts which connect the vagina with the ovaries proper. In respect to this character the Iceryines thus far studied form a series with *Icerya purchasi*, with its very short ducts, at one end, and *Crypticerya rosæ*, with its exaggerated ducts, at the other. In all these species the spermatheca is small and subject to variation in size, and indeed it may occasionally be absent entirely in *I. purchasi*. In none of the forms studied is there any evidence that it functions for the storage of sperm; after copulation the sperm from the male are found in the oviducts and the central cavity of the ovary itself, never, in many specimens examined among the different species, in the spermatheca. Neither is there ever any development of gland cells in its epithelium. Its function remains entirely problematical.

The chromosome number in the oogonia and somatic tissues of the female is four. Normal maturation figures are found in the younger eggs, showing the formation of two tetrads quite as in Icerya. Both haploid and diploid embryos are present in large numbers. The second instar nymph is a male with the somatic and spermatogonial chromosome number of two—the haploid group. Of the first instar larvæ, four are diploid, two are haploid, and two show no legible mitoses. Although incomplete, this cytological evidence certainly indi-

cates that *Crypticerya rosæ* is capable of the facultative parthenogenetic production of haploid males, while its females arise from normally fertilized eggs and are hence diploid. To be sure adult males of *Crypticerya rosæ* have never been reported, but when one considers their seasonal appearance, and the small size and great fragility of the males of closely related species, it is not surprising that the few random collections recorded for this species fail to contain any. The present discovery of haploid embryos, haploid larvæ of the first instar, and a typical haploid male nymph of the second instar, when considered in connection with the close cytological parallelism obtaining between this species and *Icerya montserratensis*, *Icerya littoralis*, and *Echinicerya anomola*, makes the existence of adult males in Crypticerya practically certain.

That the haploid embryos and larvæ arise from eggs fertilized by sperm from a male, and not from an hermaphroditic phase in the female is almost certain since the gonad of the adult female shows no traces of an earlier male phase, such as are usually apparent in adult hermaphrodites of *Icerya purchasi*. Furthermore, the young diploid larvæ of the first instar show no trace of an incipient male phase in their developing gonads, such as would be present in *corresponding* stages in the hermaphrodites of *Icerya purchasi*.

General Considerations.

Perhaps the most striking result of the foregoing studies is the fact that the functional hermaphroditism of *Icerya purchasi* emerges as a unique phenomenon, not suggested nor approached in any way by any of the other Iceryine types investigated. That this development of the hermaphroditic habit in *Icerya purchasi* is not a primitive characteristic of the species is perhaps abundantly clear from such facts as the persistence of the now entirely unnecessary males within the species, and the retention of the mating instincts of females on the part of the hermaphrodites. What is known of the biology of other members of the Margarodidæ supports the further opinion that the hermaphroditic habit can certainly not be considered a basic or primitive character of the family. Kuwana's studies on Drosicha (Warajicoccus, Kuwana '22a) and Stebbing's earlier work on Monophlebus ('04) indicate

clearly that fertilization by a male is essential for reproduction in these forms. Schrader's recent study on *Protortonia primitiva* establishes the same relationship for that species. In these forms, representing three different tribes of the Margarodidæ, there is certainly no trace of hermaphroditism. The hermaphroditic habit is thus clearly neither a family nor a tribal character, and is to be considered a secondary and derived condition in the one species now known to possess it.

Once established, functional hermaphroditism obviously offers an extremely efficient and successful mode of reproduction. With this in mind a comparison of the reproductive habits of those Margarodids now thoroughly well known in this respect becomes of interest. Schrader ('30) suggests that one reason for the extreme scarcity of *Protortonia primitiva* in its native territory and among an abundance of its food plants, is to be found in the precarious relations characterizing its mating behavior. The short adult life of the males, and the equally short period in which the females are capable of being fertilized, taken together with the great variation in length of the different larval instars under changing environmental conditions undoubtedly tend to keep the number of successful matings relatively low. To the action of this factor in Protortonia is to be added the very small size of the brood produced by the individual female. The four Iceryines of the present study, *Icerya montserratensis*, *Icerya littoralis*, *Echinicery aanomola*, and *Crypticerya rosæ*, show in one respect at least a more successful mode of reproduction. The same precarious mating conditions exist as characterize Protortonia, but the parthenogenetic production of males does much to offset this. Although the males are equally frail and short lived they are produced in such large numbers (compared with the non-parthogenetic Protortonia) that the chances of any one female being fertilized are tremendously increased. This advantage I believe to be partially offset by a weakening of the mating instinct in the Iceryine males studied. When compared with the behavior of the males of such an obligatorily bisexual species as Protortonia, the males of these Iceryines show a marked lack of ardor and a very slow and variable response to the females. When compared with either the Protortonia or the *I. montserratensis* (as an example) type of reproduction, the hermaphroditic habit of *I. purchasi* appears to be very much

more efficient; rendering the frail and short-lived males unnecessary to the propagation of the species has certainly removed the weakest point in the reproductive mechanism. My experience with these species in the field supports this general conclusion. *Icerya purchasi* shows the largest and most flourishing colonies of any of the types studied, wherever found. Its success in establishing itself in a wide range of localities following accidental introduction is an added argument. Protortonia on the other hand is much more limited in geographical distribution and very scarce and very sporadic where it does occur. The limited evidence available on the other forms would give them a position intermediate between *I. purchasi* and Protortonia in this respect.

The five Iceryine species here discussed are further remarkable, it seems to me, for an amazing degree of uniformity relative to many of their characters. In each species the males are haploid and arise parthenogenetically from unfertilized eggs. In cytological detail there is also surprising agreement. Not only are the diploid and haploid chromosome numbers the same in all, but the individual chromosomes show a close agreement in size, shape, and details of cytological behavior. The structure of the ovary is another indication of the close relationship evident throughout. The conclusion is highly probable that the mode of reproduction characteristic of this group of closely allied species will prove to be a basic character of the tribe, with the hermaphroditism of *Icerya purchasi* and the resultant reduction in its males as an isolated deviation.

The species reported in the present study represent three of the six genera comprising the Tribe Iceryini. Of the other three, nothing at all is known of the reproductive processes in Steatococcus Ferris or in Auloicerya Morrison. The remaining genus Gueriniella Fernald has been intensively studied by Vaysierre ('26). This species has a single generation per year in the Mediterranean region. The eggs are laid in mid-summer and the larvæ hatch some weeks later, but do not attach themselves to the host plant until the following spring. The actual period of development, omitting this long quiescent period, is three to four months, as in the other Iceryines. But from the point of view of the present study Gueriniella is most interesting because of the absence of males. Males are completely unknown in this species, and since it has been the subject of careful

breeding experiments by Vaysierre, this probably means that they do not exist. (Vaysierre does not, however, take up this aspect of the subject in his study.) It is possible, therefore, that Gueriniella is either hermaphroditic or obligatorily thelytokously parthenogenetic. If hermaphroditic it would seem to have carried the reduction of the males, in which process *Icerya purchasi* represents a transitional step, to its ultimate conclusion. Only a cytological examination can settle this interesting and outstanding question.

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THE MOULTING OF THE SILKWORM AND A HISTOLOGICAL STUDY OF THE MOULTING GLAND.

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Insects during the process of post-embryonic development periodically shed or moult their cuticular covering, and in addition the lining of such internal parts as are of ectodermal origin. The number of moults depends upon the number of growth periods and varies in the different species of insects. In the silkworm *Bombyx mori*, the species under observation, there are five of these growth periods, or "instars," in addition to the pupal stage. At the end of each, actual ecdysis takes place. However, sometime before ecdysis takes place, certain glands of ectodermal origin become active and liberate a fluid known as "moulting fluid," which has an important function in the process of moulting. This fluid assists in the process, and the glands furnishing the fluid are highly important organs physiologically.

The present study of the moulting of the silkworm was made during the months of April, May, and June, 1929, on some hundred specimens as they developed from the egg to adult. Silkworms were reared individually in wide-mouth fruit jars three by four inches in size. They were fed mulberry leaves two to three times a day. The temperature of the breeding room ranged from a maximum of 81° Fahr. to a minimum of 63° Fahr. The median temperature of the observation period was 72° Fahr. Observations were made constantly during the time of the moulting activity. A binocular microscope was used for close observation. All observations refer to the fourth moult, as these larger specimens permit of more accurate study, and the similarity between the first four moults is very marked. For histological study of the moulting cells whole insects were killed in boiling water, the body cut into segments, and each segment was dehydrated, imbedded in paraffine, sectioned, and stained in Delafield's haematoxylin. Mounts were made of sections of insects during the moulting period. Studies were made under an oil emersion lens. The following account is based on the results of observations.

*Contribution from the Entomological Laboratory of Stanford University, California.

The First Indications of Ecdysis

The first external indications of a change taking place in the silkworm at the time of the moult occurs about thirty-six hours before ecdysis. At this time the cuticula becomes decidedly glossy in character. There appears to be a thickening of the subcuticular layer. The increase of the chitinous substance by the chitogenous or hypodermal cells is no doubt responsible for the glossy effect characteristic of the integument of the larva. This change is gradual but is noted very definitely before there is any external sign of a new body developing within the old skin.

Shortly after this is apparent close observation shows a very slight slipping out of the tracheal lining at the dorsal point of the peritreme. This appears as a dark area or point above the spiracle. The moulting glands are functioning and the fluid is spreading rapidly between the old cuticula and the new integument forming beneath it. Thus the contacts between these two layers are being attacked and dissolved as pointed out by Tower. In time the new body is fastened to the old skin merely by the muscle attachments which are the last parts to be dissociated. As the cuticula of the peritreme becomes definitely free, the tracheal lining is pulled out at the sides so that the dark area widens laterally toward the ventral side of the peritreme and finally is complete as a circular band extending around the spiracle.

The Triangle Stage.

Following this there is a distinct change in the appearance of the head and thoracic region. This occurs after the larva is well established on the leaf with the silken mesh of threads beneath it, to which it has attached its prolegs. The larva has been inactive for several hours. Gradually there is a slight increase in color back of the larval head. The old cuticula at this point becomes turgid with included fluid. The strain on the cuticula draws the head and thorax with the fore legs into a more fixed, upright position. Within a few hours the new head is visible beneath the old cuticula. It shows as a brown, pigmented, triangular area posterior to the old head capsule with one angle of the triangle directed posteriorly and the other two angles encircling the head capsule and joining ventrally. This period is referred to as the "triangle stage" of the moult. The "triangle" when viewed under the microscope shows the chitinized texture of the new head though the markings and sutures are not definitely visible until just preceding ecdysis when the old cuticula becomes very transparent and the head has grown further back into the old prothoracic region. As the new head presses the posterior area further backward, the old cuticula becomes more and more stretched in the thoracic region. The anterior portion of the new head extends into the old head capsule, which is now dry and has hardened into a mere shell. The labium of the new head is stretched and pressed very tightly against the base of the old capsule ventrally, while the frontal portion with the clypeus and labrum is held less tightly in the dorso-anterior part. All intervening space is filled with fluid.

The transparency of the old cuticula, which makes it possible to observe the newly developed parts within, is apparent first in the region of the new head and around the peritremes where the linings of the old tracheæ are pulled loose. It seems evident that the moulting fluid must play an important part in accomplishing this thinning and consequent transparency which increases from hour to hour as the time for ecdysis approaches. The new body appears in heavy folds beneath the cuticula. This is especially evident in the thoracic region and results no doubt from the rapidly growing parts being crowded together within the confines of the outer wall of the old body.

Muscular Efforts.

About an hour or so before ecdysis certain muscular activities predict the approaching event. Throughout the "triangle stage" the larva has been inactive in its fixed position on the leaf. Now there are muscular pulls on the integument which become more and more vigorous in character. The action consists of the pulling of the old cuticula at the points of the muscle attachments. It is a rhythmical pull which centers anteriorly to the spiracle in each segment. It spreads posteriorly along the lines of the muscle attachments dorsal and ventral to the spiracle until it reaches a maximum lateral pull and effects the whole of the integument including a definite upward pull on the prolegs and true legs. Before the maximum lateral pull is noted, however, there is a dorsal pull on the cuticula at the depths of the folds of the thorax and at a mid-dorsal point of the anterior end of each abdominal segment. The lateral pull is more strenuous in the posterior segments first. The dorsal pull appears to spread from the anterior segments. This pull appears to have something to do with the spread of the moulting fluid and perhaps with its exudation from the moulting glands. When the muscular action is slight, the pull is almost simultaneous in each segment. As it increases in vigor, the cuticula is pulled in irregularly and independently at different points. The pull then appears to be localized at each point.

Fluid Pressures.

The activity in the prolegs is evident about thirty minutes preceding ecdysis when the outline of the new proleg is defined within the old capsule. At the base of each proleg there is a heavy fold of cuticula bulged out apparently with a fluid contained within, as in the case of the "triangle" area of the thorax previous to the appearance of the new head. This fluid soon fills in the area between the new proleg and the old proleg capsule. The new proleg lies freely in the liquid of the proleg capsule still attached basally by ligaments to the basal wall of the old capsule. It is now and then retracted or telescoped into its basal part by the muscular attachments. This action increases in vigor and accompanies the lateral and dorsal contractions of the body previously described.

There is definitely a pressure established within the body preceding the final shedding of the skin. This is most evident in the last twenty minutes of the moult. As the old cuticula becomes completely separated in the thoracic region, from the new, the inner body swells

and fills out and straightens the folds in the integument previously noted in this region. The new proleg becomes turgid with blood from the body cavity and forces the moulting fluid out of the old capsule. As the swelling subsides the prolegs are withdrawn from the leg capsules which consequently shrink closely to the body wall. At this time the new body within shows clearly over the entire surface, though the similarity of details of the outer and inner do not make this distinct except where the swelling of the new body has shifted the inner parts forward so that the markings contrast with those above. In the anterior region the fluid beneath the cuticula is withdrawn. This creates a suction which draws the cuticula closely to the underlying parts causing it to fall into creases. There is a general wrinkling of the outer cuticula over the whole body. It would appear that this was due also to the withdrawal of excess moulting fluid.

Air and Fluid in the Alimentary Canal.

At the time when this swelling of the inner body is noted it is evident that air is drawn into the alimentary canal. Careful observations also show that the head capsule is filled with a fluid which is constantly sucked backwards. By pulling away parts of the old head capsule so as to expose the new head and pharyngeal cavity, the fluid, which fills all the space within the old capsule not occupied by the new head, can be drawn off in droplets. Normally this fluid which continues to gather throughout this period is taken care of within the body as none is evident here at the time of ecdysis. Observations show that this fluid is sucked internally into the alimentary canal. As the fluid ceases to gather, the sucking movements continue thus drawing air into the alimentary canal until ecdysis is complete.

Monnier (1872) in aquatic larvæ, de Bellesne (1877) in Odonata, Herculais d' Kunckel (1890), Knab (1919, 1911), Shafer (1923) have all recognized the fact that mechanical pressure forces the blood against the body wall and thus enables it to exert a pressure against the outer integument which accomplishes the rupture at ecdysis, and that this pressure is established by an accumulation of air in the alimentary canal. Monnier (1872) first recognized the presence of air in the alimentary canal and its function, but de Bellesne first observed that this air was swallowed by the insect. The swallowing of liquid has not been previously noted, though Shafer noted the presence of a "fluid more viscous and less transparent than water" in the alimentary canal of Odonata after the moult.

In the silkworm there is a throbbing action in the clypeal region of the head accompanying the sucking movement of the pharynx. The tissue is drawn in at regular intervals. The fluid collects within the mouth cavity in the epipharyngeal region. Though no moulting glands have been found located in the head and the origin of the fluid is not explained, yet it seems to be related to the moulting fluid. As the mouth cavity is filled with fluid, the open mandibles close upon it and work it backwards with a regular and vigorous pull. At the same time the hypopharynx works in the same direction and within a minute, or less, of the time when the mouth cavity is full, the fluid is

sucked into the alimentary canal and the mouth cavity is empty again. There appears to be no excess of fluid drawn away with the stomodaeum when it is pulled away with the head capsule either artificially or naturally. It would appear therefore that all the excess fluid as well as that which appears to gather within the mouth cavity at this time is gulped down the oesophagus with or before air is swallowed. The effect of swallowing fluid and air would be to dilate the digestive tube. The fixed quantity of blood in the body, as pointed out by Knab, Shafer, and others, is driven to the periphery of the haemocoel by pressure exerted by the dilated digestive tube, thus obtaining the necessary force to accomplish ecdysis.

It may be noted here that this is the same mechanism which initiates and accomplishes the expansion of the wings of the young imago, by means of blood forced out through them, and also aids certain insects to elongate the body for the purpose of ovipositing, (Herculais d' Kunckel, 1894). It is this mechanism which enables certain insects at least to effect the hatching process from the egg covering, (Hubbard, 1885, *Psocid citricola* Ash; Peyerimhoff, 1901, *Stenopsocus cruciatus* L.; Wachter, 1925, *Ectopsocus californicus* Banks.)

The principle of the inflation of the digestive tube with air, as fundamental in the moulting, hatching, and other processes in insects is thus a well-established one. In addition, as here pointed out, more or less liquid secretion is also drawn into the digestive tract. Muscular exertions unaided appear to be inadequate to liberate the insect from the exuviæ, as Knab and others have stated. The new chitinous cuticula is too soft to offer much resistance to the pull of the muscles now inserted here.

The Ecdysis.

The maximum swelling due to the air and fluid which is being steadily drawn into the digestive tract exerting a pressure upon the body wall occurs in the anterior of the body immediately preceding ecdysis. Simultaneous with the swelling there is a shortening and lengthening in the horizontal direction between the segments. This activity begins in the posterior segments and advances in waves forward. It arises first in the region of the sixth abdominal segment but the initiation of the wave recedes to the seventh, eighth and posterior region of the body before ecdysis is complete. As the forward part of the body is forced against the contact between the head capsule and the thoracic cuticula, the pressure becomes so great that a rupture in the old cuticula results. This is a circular tear starting near the labium at a mid-ventral point and extending around the old head capsule where it is attached to the neck membrane. With the first break in the cuticula the new body bulges out and appears as a small nob at the base of the head but this disappears immediately as the slit continues around the lateral contacts. The contact at the mid-dorsal point holds just long enough to cause the head to be drawn up and back. This last attachment snaps quickly. The head is now greatly inflated with blood, and when the rupture is complete the posterior parts of the new head are grasped tightly by the neck membrane thus avoiding any loss of pressure within the body necessary for the com-

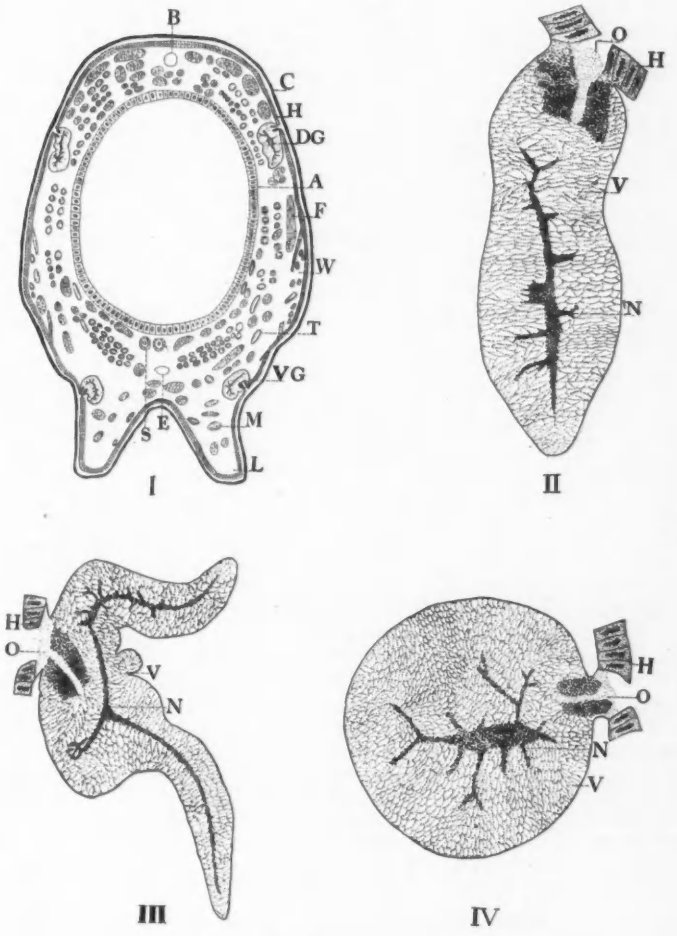
pletion of the moult. The rupture is sudden, and the old head capsule is expulsively thrown off followed by a forward movement of the new body out of the old cuticula. After the rupture the head assumes a normal position and the old capsule, which is the only part forced off by the rupture, sometimes clings to the anterior end enclosing the new mandibles until it is removed by rubbing it against the leaf or with the aid of the fore legs. The slipping off of the old skin takes about a minute.

As previously stated, a forward movement of the body begins beneath the old integument before the rupture takes place. The anterior prolegs are entirely withdrawn from their capsules. The second, third, and fourth abdominal segments apparently are the first to move forward, as here the tracheal linings are seen to be pulled out from the corresponding tracheæ as these segments move forward. The tracheal linings, now apparently without air, are seen stretching along the side of the body backward from the new spiracle to the old. The first and fifth abdominal segments then take part in the movement as evidenced by the relation of the corresponding exuviated tracheal tubes and their corresponding spiracles, old and new. The lining of the thoracic tracheal tube now slips out in a dorsal direction instead of posteriorly as in the case of the other tracheal tubes. The pressure here is upward as the thorax is swelling previous to the rupture. The thoracic tracheal linings and the linings of the tracheæ in the posterior three abdominal segments are the last to be pulled out of their corresponding tracheal tubes, and hence the corresponding spiracles are presumably the last to remain functional during the process of tracheal ecdysis. The posterior tracheal linings remain intact after the rupture, and after the slipping back of the old cuticula at the anterior of the body has begun. The backward movement of the cuticula is so rapid after the rupture actually takes place that the spiracles of the anterior end of the body begin to function before the tracheal linings are pulled out of their corresponding tracheal tubes in the posterior end of the body. Thus there is almost no interval when respiration may not take place either at the posterior or anterior end of the body during moulting.

The Moulting Glands and Their Fluid.

Newport (1832) is said by Packard to be the first one to have observed the moulting fluid. However, according to Swammerdam Malpighi, Professor of Physics and Philosophy in Bologne, publishing his observation on the Metamorphosis of the Silkworm in 1669, states with reference to the pupal ecdysis that "this process is assisted greatly by a yellow kind of ichor or fluid which breaks forth in the cavities of the skull." The gland cells which furnish this fluid have been designated by Holmgren (1895) as Verson's glands, as it was he who made the first detailed study of these glands in the silkworm.

In the silkworms under observation at a time preceding the moult from ten to thirty hours, these glands have a very similar structure in all segments but differ somewhat in size, position, shape, and distribution of nuclear material. Each gland is a single giant cell. The nuclear



THE MOULTING GLANDS OF THE SILKWORM.

Fig. 1. Cross-section through metathorax. DG, Dorsal moulting gland. VG, Ventral moulting gland. A, Gut. B, Aorta. C, Old cuticula. E, Nerve cord. F, Fat cells. H, Hypoderm. L, Leg. M, Muscle. S, Silk gland duct. W, Position of imaginal wing in sections posterior to this. T, Trachea.

Fig. 2. Dorsal gland of third abdominal segment.

Fig. 3. Dorsal gland of first abdominal segment.

Fig. 4. Dorsal gland near anal horn of eighth abdominal segment. O, Opening of gland. H, Hypoderm. V, Vacuolated cytoplasm. N, Nucleus.

material is spread out along the line of the length of the cell, (Figure II-N). Fine radiations from the main branches are numerous especially at the wider portions of the gland. In some cells it is concentrated in the central region with branches extending from this, (Figure IV-N). If the gland has finger-like lobes, the branches of nuclear material extend into these lobes, (Figure III-N). Outside of the nuclear material the gland is distinctly vacuolated everywhere (Figures II, III, IV -V) except at the point where it is in contact with the hypodermal layer. Certain hypodermal cells surround the tubular duct of the gland and appear as a guard to that opening. The intima of the normal hypodermal cells appear to be continuous around the surface of the gland.

As determined by Verson, there are fifteen pairs of moulting glands in the silkworm. They are large and conspicuous and situated as follows: A dorso-lateral pair in each thoracic and each abdominal segment, namely eleven dorso-lateral pairs of glands; a pair at the base of each of the thoracic legs, namely, three latero-ventral thoracic pairs; and a pair at the base of the anal horn. The dorso-lateral glands are found in the anterior half of each segment and extend backward within the segment. Antero-posteriorly, these glands vary little in length from segment to segment. Ventro-dorsally, there is a slight difference in the vertical and horizontal diameters. Those in the anterior abdominal segments have a vertical diameter twice or three times that of the horizontal diameter, (Figure II). Those in the posterior segments appear about the same in vertical and horizontal diameters, (Figure IV). There is considerable irregularity in the width of these glands as a whole, as observed in cross sections, (Figures II, III, IV). The shape of the glands is in general elongate-tubular with many irregularities in the form of finger-like extensions, (Figure III). In the same segment the gland on one side may be regular in its long, narrow form while that on the other has projecting lobes. This irregularity would indicate that the shape varies with the functioning of the gland. The glands in one area may function at a different time from those in another area. The dorso-lateral glands are all located about midway between the spiracle and a mid-dorsal line, and open at the surface dorso-laterally, (Figure I–DG). The pair at the base of the dorsal horn of the eighth segment is very close to the mid-dorsal line. Each one opens to the surface on either side of the dorsal blood vessel. The ventro-lateral glands are located just above the attachment of the leg to the body and open ventrally at the base of the leg, (Figure I–VG).

Summary.

In the previous observations, several important physiological features of the moult are noted. The first of these is the formation of an inner layer of chitin by the hypodermal cells active as chitogenous cells. This is perhaps the first step in the moulting process. At this time the insect has barely ceased feeding, and the last pellet of foecal matter has not been eliminated. The insect is in the stage which might be called

the "glossy stage." Packard considers that the "formation of the new layer of chitin arrests the supply of nourishment to the old skin, so that it dries, and hardens. The next step is the exudation of the moulting fluid which spreads out as a thin sheet of liquid between the old and new cuticula and finally fills all available pockets such as the head capsule, the proleg and leg capsules, and the dorsal horn as the respective parts are withdrawn from these. This fluid is an important feature of the process of moulting. It is furnished by certain highly-modified hypodermal glands known as "exuvial glands."

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A DESCRIPTION OF THE MALE OF PROCERATIUM CROCEUM EMERY, WITH REMARKS.

M. R. Smith,
A. & M. College, Mississippi.*

Although the genus *Proceratium* was erected by Roger in 1863, the few species in this genus are known only from the worker and female phases. This has been due probably to the following reasons: either that myrmecologists have neglected to describe the males which they have collected, or they have not been fortunate enough to find the males associated with the females or workers, or they have failed to collect the males at all.

Three species with several subspecies and varieties have been recorded for North America. The most common of these in Mississippi, at least, is the species *P. croceum*, the colonies of which I have usually found in rotting stumps and logs. Although this is not a rare ant in Mississippi, it is by no means a common species. The colonies of *P. croceum* are very small. In one of the largest colonies that I have found there was a dealate queen and 30 workers. In a smaller colony I found 1 dealate female and 11 workers. It is not unusual to find a single dealate queen alone.

During the summer of 1929 I was fortunate enough to find a colony of *P. croceum* which in addition to workers contained both alate males and females. From some of these specimens I have drawn the description given below. Since this is the first male to be described for the genus I have thought it advisable to present figures also.

I am indebted to Dr. W. M. Wheeler for his opinion concerning the taxonomical status of the ants, and to Mrs. G. G. DeBord for the accompanying illustrations.

Proceratium croceum (Roger).

P. croceum (Roger), Berl. Ent. Zeitschr., Vol. 4, p. 288 (1860), female (*Ponera crocea*).

Sysphingia? crocea, Mayr, Sitzungsb. Akad. Wiss. Wien, Vol. 53, p. 501 (1866), female.

P. croceum Mayr. Verh. Zool. Bot. Ges. Wien, Vol. 36, p. 437 (1886); Emery, Zool. Jahrb. Syst. Vol. 8, p. 264, Pl. 8, f. 5, 6 (1895), worker and female.

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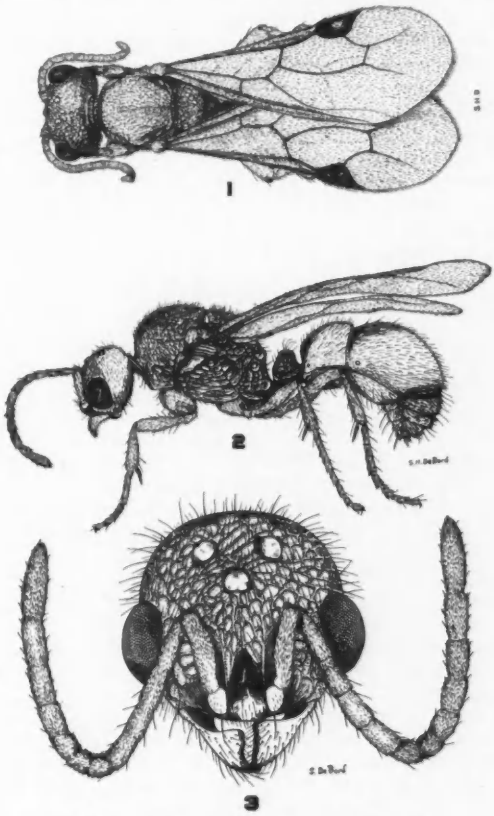
* A contribution from the Mississippi Agricultural Experiment Station.

Male. Length: 3.75–4.25 mm.

Head, excluding the mandibles, slightly broader than long when measured from side to side through the center of the eyes, posterior border and posterior angles strongly rounded. Vertex with 3 fairly prominent ocelli, the distance between one of the lateral and the median



Male of *Proceratium croceum* (Roger)
Fig. 1, Dorsal view of body. Fig. 2, Lateral view of body.
Fig. 3, Anterior view of head. (All greatly enlarged.)

ocellus less than that between the two lateral ocelli. Eyes large and prominent, oblong-oval, strongly convex. Antennæ 13-segmented, subfiliform; scape short, moderately stout, not attaining the anterior border of the median ocellus; last funicular segment slightly longer than the two preceding segments taken together. Frontal carinæ

short, subparallel, not concealing the pedicels of the scapes. Region of the frontal area deeply impressed. Anterior border of the clypeus broadly, but gently emarginate medianly. Mandibles well developed, subtriangular, the apical margins of each edentate and strongly sinuate, terminating in a sharp apical point. Thorax short and massive. Pronotum well developed, easily discernible dorsally, with rather distinct humeral angles. Mesonotum without Mayrian furrows but with fairly distinct parapsidal sutures posteriorly, the anterior median portion of mesonotum subtruncate, and fitting into the deep, central emargination of the posterior border of the prothorax. Wings sordid brownish; pilose throughout, and with ciliated margins; the anterior pair, each with a very large and distinct stigma, and an open radial cell, a closed cubital cell, but no discoidal cell. Scutellum with a distinct median carina posteriorly. Metanotum terminating centrally in a large, pointed tooth or tubercle. Base of epinotum distinctly shorter than the declivity, the two, meeting in a very definite angle; at the point of their junction there is a deep median furrow which extends throughout most of the base of the epinotum. Distal end of the tibia of each leg with a single, well defined spur. Petiole with the anterior surface decidedly declivous, on each side, the declivous surface more or less bounded by a lateral border which terminates antero-ventrally in a small, blunt tooth or tubercle; superior margin entire, rounded from side to side, and rather abruptly meeting the very short and somewhat vertical posterior surface; ventral surface with a lamellar plate, which is backwardly directed. Gaster oblong, the apex reflexed but not quite so strongly as with the worker or female; the first segment truncate at base, meeting the second segment in a very strong constriction; the second segment large, easily occupying more than one half of that portion of the dorsum which is visible from above; genitalia capable of being extruded or retracted.

Mandibles, clypeus, frontal area, scapes of antennæ, anterior surface of petiole, legs, and gaster smooth and shining; remainder of body subopaque. Head, thorax, and petiole, rugulose-reticulate; the sculpturing on the head somewhat fine, that on the thorax heavier, especially on the pleuræ of the prothorax, and on the epinotum; petiole also similarly sculptured.

Pilosity golden yellowish; suberect? moderately dense, covering all parts of the body. Pubescence of the same color as the pilosity, dense, covering all parts of the body, but less abundant and less conspicuous on the pleuræ of the thorax; in some lights the pile and pubescence give the body a burnish golden tinge.

Ferruginous; head, dorsum of thorax, petiole and gaster infuscated.

Described from three alate males, which, with a large number of alate females, and workers were collected from several cavities in a rotting pine log, 4 miles north of Aberdeen, Mississippi, on August 19, 1929.

Cotypes are in the collection of the Department of Entomology of the Mississippi A. & M. College, and my collection.

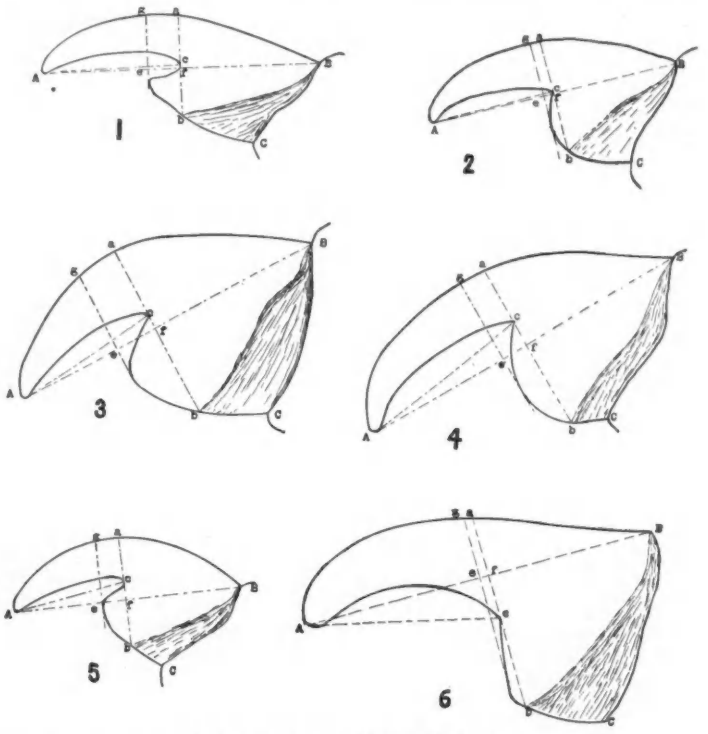
TARSAL CLAWS OF NOCTUID LARVÆ.

J. H. Hawkins,
Agricultural Experiment Station, Orono, Maine.

All species of noctuid larvæ have many characteristics in common and certain closely related forms are similar even to minute structural detail. Species of different genera are sometimes so much alike that they can scarcely be identified in the larval stage. Taken as a whole the group offers serious difficulties for the taxonomist and it has been found necessary to rear some species to the adult stage in order to identify them. Natural colors of these caterpillars are sometimes specific, but unfortunately color patterns of preserved specimens are not always reliable. At the present time no single character is known which is variable with the species sufficiently to be of use in the taxonomy of the whole family. A comparative study of many details of form and structure is a prerequisite of the identification of certain species of noctuid larvæ. Consequently any character which is constant in form within a species and variable within the family may serve as an aid to the identification of unknown specimens. Tarsal claws of noctuid larvæ are fairly constant for the species and are commonly of different forms and proportions in different species.

Before explaining methods of comparison a general description of a typical tarsal claw may be helpful. The broad base of the claw is attached to the distal extremity of the tarsal segment by a whitish, flexible membrane which forms a triangle on the lateral aspect of the claw. The two sides of the triangle are the base and the ventral margin of the claw respectively and the hypotenuse is the line separating the membrane from the sclerotized distal portion. (Fig. 1, BCb.) A somewhat tapering hook, curved in a ventrad direction, extends distally from the dorsal portion of the base and a convex angulate process, much shorter than the hook is produced distally from the ventral portion of the base and for convenience in this paper is termed the sole. Occasionally the sole may be only a flattened surface projecting but little or even receding towards the base. (Fig. 6.) That there are variations in the length,

shape and curvature of the hooks is shown in a comparison of the claws of *Euxoa messoria* Harr. and *Agrotis unicolor* Walk. (Figs. 1 and 2.) The claw of the hook of *E. messoria* is proportionally narrower at its base, slightly less curved and less tapering than that of *A. unicolor*. However, the greatest



TARSAL CLAWS OF NOCTUID LARVAE.

Fig. 1. *Euxoa messoria* Harris.
Fig. 2. *Agrotis unicolor* Walk.
Fig. 3. *Agrotis c-nigrum* L.
Fig. 4. *Cirphis unipuncta* Haw.
Fig. 5. *Polia meditata* Grote.
Fig. 6. *Nephalodes emmedonia* Cram.

difference between the claws of these two species lies not in their hooks but in their soles. The sole of *E. messoria* is an angular process while that of *A. unicolor* is merely a rounding of the distal margin of this region. These two species bear claws which are so different that a simple comparison is sufficient

for one to distinguish them from each other. In other species the differences are less obvious and it is necessary to make careful measurements and comparisons, if they are to be disclosed. Figures 3, 4, 5 and 6 illustrate other forms of tarsal claws of this group of larvæ.

It is sometimes desirable to establish differences of a minute character in the study of tarsal claws. In order to demonstrate such differences, enlarged photographs can be made by using a photomicrographic camera. These photographs can then be reversed, their outlines traced, and lines drawn as follows: AB is drawn from the distal extremity of the hook to the dorsal margin of the claw at the point of junction with the tarsus (Fig. 1); ab is drawn perpendicular to the line AB through the point of junction of the hook and the sole. The ratio of the length of the line AB to the length of the line ab represents the ratio of the straight line length of the sclerotized portion of the claw to the transverse dimension; the line ab striking the margin of the claw at or near the proximal limits of sclerotization. Decrease in the length of the line AB in proportion to the length of ab is usually associated with a corresponding increase in curvature of the hook. The line eg is drawn parallel to ab through the most distal point on the margin of the sole and the line ef represents approximately the distal limits of the curve or angle, as the case may be. The line ab striking the ventral margin at the point b, marks approximately the distal limits of the membraneous portion of the claw and represents the approximate width of the distal curve. Ac is a chord connecting the extreme limits of the ventral curve of the hook and represents the straight line length of that part of the claw.

Ratios obtained by dividing the unit length of various lines, representing different parts of the tarsal claw as described above, have been found useful in obviating the necessity of having all claws to be compared photographed at the same magnification. They should be photographed from the same angle however, and it is better to use the claws from corresponding legs of larvæ being compared. Claws can be transferred from 95 per cent alcohol to carbo xylol and after clearing can be mounted on slides in balsam. They can be manipulated in the balsam with a needle wet in carbo xylol and should be mounted flat on the slide so that all the mounts to be compared present the same lateral aspect.

Claws of several species of noctuid larvæ have been measured and the ratios are presented in the accompanying table. The ratios are as follows: AB to Ac the length of the sclerotized portion of the claw to the length of the hook, both being straight line lengths; ab to ac the width of the claw to the width of the hook at its base; ab to cb the width of the claw to the width of the sole; and cb to ef represents the ratio of the width of the sole to its altitude.

TABLE OF RATIOS.

PARTS OF TARSAL CLAWS.

	AB : Ac	ab : ac	ab : cb	cb : ef
Euxoa messoria Harr.	2.00	2.00	2.00	1.58
Euxoa tessellata Harr.	2.56	1.50	3.00	2.75
Euxoa ochrogaster Guen.	2.03	1.90	2.11	3.80
Feltia gladiaria Morr.	2.25	2.09	1.91	3.50
Feltia ducens Walk.	1.90	1.15	1.42	2.87
Feltia herilis Grt.	2.28	1.80	2.45	2.25
Feltia volubilis Harv.	2.13	2.04	1.95	3.63
Feltia annexa Treit.	2.66	2.27	1.79	2.33
Feltia malefida Guen.	2.19	2.18	1.84	3.12
Agrotis ypsilon Rott.	1.97	2.00	2.00	5.00
Agrotis c-nigrum L.	2.15	1.53	1.65	2.35
Agrotis bicarnea Guen.	2.11	2.25	1.80	5.00
Agrotis normaniana Grt.	2.05	2.63	1.92	5.55
Agrotis phyllophora Grt.	1.97	2.21	1.82	5.11
Agrotis fennica Tausch.	2.09	2.05	1.95	2.22
Agrotis unicolor Wlk.	2.04	2.15	1.86	7.33
Lycophotia occulata L.	2.06	2.01	1.90	5.50
Lycophotia margaritosa Haw.	2.18	2.52	1.68	4.83
Lampra brunneicollis Grt.	2.20	2.04	1.83	8.00
Polia imbrifera Guen.	1.80	3.43	1.41	3.66
Polia meditata Grt.	2.29	2.15	1.56	2.85
Polia legitima Grt.	1.76	2.05	1.91	2.12
Polia renigera Steph.	2.04	2.52	1.65	2.66
Nephalodes emmedonia Cram.	1.73	1.75	2.33	7.50

The Entomological Society of America

CONSTITUTION.

(As amended to date, January 1, 1930.)

ARTICLE I.

NAME.

SECTION 1. This organization shall be known as The Entomological Society of America.

ARTICLE II.

OBJECT.

SECTION 1. It shall be the purpose of this Society to promote the science of entomology in all its branches, to secure cooperation in all measures tending to that end, and to facilitate personal intercourse between entomologists.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The membership of this Society shall consist of three classes: members, fellows and honorary fellows.

SEC. 2. All persons interested in entomology shall be eligible to membership.

SEC. 3. Members who have made important contributions to the science of entomology may be elected fellows or honorary fellows of the Society.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of this Society shall be a President, two Vice-Presidents, a Secretary and a Treasurer, but these two last offices may be held by the same person.

SEC. 2. Executive Committee.—The business of the Society not otherwise provided for shall be in the hands of an Executive Committee, consisting of the Officers named in Section 1, and six additional members, five of whom shall be elected from the Fellows of the Society, and the sixth shall be ex-officio the Managing Editor. There shall be a meeting of the Executive Committee at each Annual Meeting. Four members shall constitute a quorum and in the case of the non-attendance of this number at any Annual Meeting, the Society shall elect a sufficient number from among the Fellows in attendance to complete the quorum.

SEC. 3. Councillors to the American Association.—Two representatives on the Council of the American Association for the Advancement of Science shall be elected by ballot at the Annual Meeting for a term of one year, and shall be eligible for re-election. In case of the death, resignation, absence or inability to serve of either or both councillors, the vacancy shall be filled by the Executive Committee.

ARTICLE V.

ELECTIONS.

SECTION 1. Election of Members.—Nominations for membership may be made by any two members, and election shall be by the Executive Committee.

SEC. 2. Election of Fellows.—All nominations for fellows shall be signed by three or more fellows and each nomination shall be accompanied by the following information concerning the nominee: Name, address, occupation, branches of entomology engaged in, positions held involving entomological experience, entomological work done, and list of more important publications. Election shall be by ballot by the Executive Committee, a majority vote of the Committee being necessary for election.

SEC. 3. Election of Officers.—All officers shall be elected by ballot at the Annual Meeting for the term of one year and shall be eligible for re-election.

SEC. 4. Election of Honorary Fellows.—Honorary Fellows may be nominated by unanmious vote of the members of the Executive Committee present at an annual meeting. The nominee shall be voted on by the members by ballot, and must receive four-fifths of all ballots cast to be elected. Not more than one Honorary Fellow may be elected in three successive annual meetings.

ARTICLE VI.

MEETINGS.

SECTION 1. An annual meeting shall be held in affiliation with the American Association for the Advancement of Science, or at such time and place as the Executive Committee may select.

ARTICLE VII.

PUBLICATION.

SECTION 1. Publication.—The official publication of the Society shall be known as the Annals of the Entomological Society of America. Each volume shall consist of four fascicles and the first fascicle of each volume shall contain the proceedings of the Annual Meeting.

SEC. 2. Editorial Board.—The publication shall be under the charge of an Editorial Board consisting of ten members, one of whom shall be the Managing Editor. The Managing Editor and his associates shall be responsible for the selection of material to be published.

SEC. 2. Election of Editorial Board.—The members of the Editorial Board shall be elected by the Executive Committee. Each member of this Board, excepting the Managing Editor, shall serve for three years or until his successsor has been elected, three members retiring annually.

SEC. 4. Report of Managing Editor.—The Managing Editor shall present a report at each Annual Meeting to the Executive Committee and the accounts of his office shall be reported upon by the Auditing Committee.

ARTICLE VIII.

THOMAS SAY FOUNDATION.

SECTION 1. Name.—There is hereby established a standing committee of the Society under the name of "The Thomas Say Foundation."

SEC. 2. Purpose.—The purpose of this Foundation is for the publication of the works of a monographic or bibliographic character on the insects of North America.

SEC. 3. Publication.—Each publication shall be a volume complete in itself, and numbered consecutively.

SEC. 4. Committee.—This committee shall consist of six members, four of them to be elected by the Executive Committee of the Society, two of them retiring annually, and an Editor and a Treasurer to be designated by the Executive Committee.

SEC. 5. Powers.—This Committee is empowered to determine all matters concerning the publication.

SEC. 6. Funds.—They are also empowered to solicit, hold, invest, and expend funds committed to their care; only the interest of any endowment to be available.

SEC. 7. Responsibility.—The Society shall be in no way responsible for debts contracted by this Foundation, unless previously authorized by the Executive Committee.

SEC. 8. Reports.—The Editor and Treasurer shall present a report of their operations and expenditures to the Executive Committee at each Annual Meeting, and the accounts of the Treasurer shall be audited by the Auditing Committee of the Society. These reports shall be published as a part of the proceedings of the Executive Committee of each Annual Meeting.

ARTICLE IX.

AMENDMENTS.

SECTION 1. This constitution may be altered or amended at any annual meeting by a two-thirds vote of the members present, a copy of each amendment proposed having been presented at the previous annual meeting.

BY-LAWS.

1. The annual dues for members and fellows shall be three dollars.

2. A majority of the members present at an annual meeting shall constitute a quorum for the transaction of business.

3. Notice of all meetings of the society shall be sent to all members at least one month in advance.

4. The Executive Committee shall provide a program for all meetings, including at the annual meeting a popular lecture and a technical entomological exhibit of materials and methods.

5. The time of the business shall be published prior to the opening session of the annual meeting.

6. Any member may become a life member upon payment of $50.00 at one time, and shall be exempt from further assessment. He shall receive during his life, one copy of each issue of the Annals.

7. Members two years in arrears shall be dropped from the rolls by the secretary after twenty days notice.

8. A member elected shall not be in good standing until he pays his first years dues. In case he shall not have made such payment at the expiration of one year from the date of election, he shall be dropped from the roll by the secretary after twenty days notice.

9. The Annals of the Entomological Society of America will not be mailed to any fellow or member whose dues are in arrears. All dues are payable December 1, and should be received not later than March 1.

LIST OF MEMBERS

Entomological Society of America

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small caps and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

'26. Abbott, Cyril E., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Behavior.*
'28. ADAMS, CHAS. F., State Bd. Health, Indianapolis, Ind. (F. '29). *Mycetophilidæ.*
'28. Adkins, T. R., 801 Smith Young Tower, San Antonio, Texas.
'08. Ainslee, C. N., 2000 S. St. Aubin Street, Sioux City, Iowa. *Hymenoptera.*
Ch. *ALDRICH, J. M., National Museum, Washington, D. C. (F. '07). *Diptera.*
'10. ALEXANDER, C. P., Mass. Agr. College, Amherst, Mass. (F. '07). *Tipulidæ.*
'13. Allee, W. C., Zool. Bldg., Univ. of Chicago, Chicago, Ill. *Behavior.*
'26. Allen, H. W., Jap. Beetle Lab., Moorestown, New Jersey. *Tachinidæ.*
'30. Anderson, Edwin J., Agr. Exp. Sta., State College, Pa.
'29. Anderson, L. D., 1621 Edgehill Road, Lawrence, Kansas.
'26. Andrews, Arthur W., 133 Tyler Ave., Detroit, Mich. *Coleoptera.*
'28. App, Bernard A., 67 N. Liberty Street, Elgin, Ill.
'23. Armstrong, Thomas, Ent. Lab., Vineland Sta., Ontario. *Scarabaeidæ.*
'22. Arnold, Geo. F., State Plant Bd., A. & M. College, Miss. *Cerambycidæ.*
'26. Atkinson, Norman J., State Nat. Hist. Survey, Urbana, Ill. *Noctuidæ.*
'29. Atwell, H. C., 101 Court House, Portland, Oregon.
'29. Audant, Andre, Dept. Ent., State Agr. College, Manhattan, Kan. *Cotton Ins.*

'18. Babcock, O. G., Box 407, Sonora, Texas. *Mallophaga, Anoplura.*
'26. Babiy, Paul P., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Hymenoptera.*
'22. Baerg, W. J., Univ. Ark., Fayetteville, Ark. *Poisonous Anthropods.*
'30. Bailey, J. W., Box 107, Univ. Richmond, Richmond, Va. *Myriopoda.*
'19. Baird, A. B., 228 Dundas Street, E. Belleville, Ontario. *Parasitic Hymenoptera.*
'11. BAKER, A. C., Bur. Ent., Washington, D. C. (F. '29). *Aphididæ, Aleyrodidæ*
'12. Baker, A. W., Ontario Agr. College, Guelph, Canada. *Mallophaga.*
'22. Baker, Howard, Box 1715, Shreveport, La. *Pecan Insects.*
'28. Baker, W. L., Dept. Zool., Univ. of Minn., Minneapolis, Minn.
'28. Balch, Reginald E., Forest Insect Field Station, Coeur D'Alene, Idaho.
'19. Balduf, W. V., 610 Michigan Ave., Urbana, Ill. *Chalcidoidea, Decatoma.*
Ch. *BALL, E. D., Univ.of Ariz., Tuscon, Ariz. (F. '08). *Cicadellidæ, Membracidæ, Fulgoridæ.*
'26. Ballou, Chas. A., Jr., Eton Hall, Belmoy Rd., Scarsdale, N. Y. *Coleoptera.*
'22. Banghart, Joseph, 934 Hollister St., Olney, Ill. *Lepidoptera, Coleoptera.*
Ch. Banks, C. S., 1411 Leveriza, Malate, Manila, P. I. *Diptera, Hemiptera.*
'08. BANKS, NATHAN, Mus. Comp. Zool., Cambridge, Mass. (F. '14).
Ch. Barber, H. G., 143 E. Third Ave., Roselle, N. J. *Hemiptera.*
Ch. BARBER, H. S., U. S. National Museum, Washington, D. C. (F. '28). *Lampyridæ.*
'23. Bare, C. O., Box 1525, Sanford, Fla. *Notonectidæ, Parasitic Hymenoptera.*
'29. Bare, O. S., 1535 N. 32nd St., Lincoln, Neb. *Formicidæ, Carabidæ.*
Ch. Barlow, John, State College, Kingston, Rhode Island.
'27. Barnes, H. F., Rothamsted Exp. Sta., Harpenden, Herts., Eng. *Cecidomyidæ.*
'28. Barnes, O. L., U. S. Entomological Labr'y, Tempe, Ariz.

'28. Barrett, R. E., Box 171, Saticoy, Calif. *Coleoptera.*
'22. Bartley, H. N., 22 Elizabeth Street, So. Norwalk, Conn.
'18. Basinger, A. J., Citrus Exp. Sta., Riverside, Calif. *Citrus Insects.*
'22. Batchelder, Chas. H., 170 Beech Ave., Melrose, Mass. *Insect Pathology.*
'24. Beamer, Raymond H., 1000 Missouri Street, Lawrence, Kan. *Cicadidæ.*
'29. Bedard, Wm. D., 334 Clairmonte Ave., Syracuse, N. Y.
'20. Bedford, Hugh W., Khartoum, Sudan, Africa.
'24. Beebe, Wm., 33 W. 67th Street, New York, N. Y.
'26. Bell, Ernest L., 438 Amity Street, Flushing, N. Y. *Hesperiidæ.*
'30. Bell, Horace E., c/o University Store Co., Orono, Maine.
'26. Belon, Fernando, Apartado 133, Arequipa, Peru, South America.
'15. Benjamin, Foster H., Box 2080, Orlando, Florida. *Lepidoptera.*
'30. Benkert, Lysbeth H., Dept. Zool., Univ. of Pittsburgh, Pittsburgh, Pa.
Ch. Bentley, G. M., 406 Morrill Hall, Univ. of Tenn., Knoxville, Tenn.
'23. Benton, Curtis, Box 495, W. Lafayette, Ind. *Ecology.*
'17. *Bequeart, J. C., Harvard Med. Sch., Boston, Mass. *Hymenopt., Dipt.*
'09. Berger, E. W., St. Plant Board, Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
'29. Berland, Lucien, 45 Rue De Buffon, Paris, Ve , Fr. *Arachnaidæ, Hymenopt.*
'28. Berley, J. A., Div. Ent., Clemson College, S. Car. *Coccidæ.*
'28. Berryhill, Ira W., U. S. D. A., McAllen, Texas.
Ch. BETHUNE, CHARLES J. S., 16 Washington Ave., Toronto, Canada. (F. '06, HF. '14).
Ch. Betten, Cornelius, 3 The Circle, Ithaca, N. Y. *Trichoptera.*
Ch. BEUTENMULLER, WM., 85 Elm Street, Tenafly, N. J. (F. '08). *Cynipidæ.*
'28. Bibby, F. F., Div. of Ent., College Station, Texas.
'28. Bieberdorf, G. A., A. & M. College, Dept. Ent., Stillwater, Okla. *Aphididæ.*
'26. Bigger, J. H., 1114 S. Main St., Jacksonville, Ill.
'13. Bilsing, S. W., College Station, Texas. *Cerambycidæ, Acrididæ.*
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. *Noctuidæ.*
'27. Bird, R. D., Dept. Zoo., Univ. Okla., Norman, Okla. *Tenthredinoidea.*
Ch. BISHOP, F. C., Bur. Ent., Washington, D. C.(F. '28). *External parasites.*
'24. Bishop, S. C., Dept. Biol., Univ. Rochester, Rochester, N. Y. *Arachnidæ.*
'26. Bissell, Theo. L., Experiment, Georgia. *Aphididæ.*
'13. Blackman, M. W., State College, Forestry, Syracuse, N. Y. *Timber beetles.*
Ch. BLAISDELL, F. E., Acad. Sci., G. Gate Park, San Francisco, Cal. (F. '25). *Tenebrionidæ, Melyridæ.*
'28. Blanchard, Ralph A., 600—26th Street, Sacramento, Calif. *Homoptera.*
'26. BLATCHLEY, W. S., 1558 Park Ave., Indianapolis, Ind. (F. '27). *Coleoptera, Orthoptera, Heteroptera.*
'28. Blauvelt, Wm. E., 214 Thurston Ave., Ithaca, N. Y.
'29. Boesel, M. W., Dept. Zool., Miami University, Oxford. Ohio. *Chironomidæ.*
'26. Bolster, Percy G., 217 Norfolk St., Dorchester Center, Boston, Mass.
'26. Booth, O. E., 907 Clinton Ave., Des Moines, Iowa.
'28. Borror, D. J., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Odonata.*
'14. BÖVING, A. C., U. S. Nat. Mus., Washington, D. C. (F. '29). *Coleopterous larvæ.*
'24. Bowe, Martin, 27 Gladstone St., Providence, R. I. *Coleoptera.*
'29. Bowen, Nylos F., 441 N. 5th East, Logan, Utah.
'17. Bowers, H. L., 31 N. Eastfield Ave., Trenton, New Jersey.
'19. Bradley, George H., Mound, La. *Diptera.*
Ch. BRADLEY, J. C., Cornell, Ithaca, N. Y. (F. '14). *Vespidæ, Scoliidæ.*
'12. Branch, Hazel E., 3756 E. Douglas Ave., Wichita, Kan. *Chironomidæ.*
'26. Brandhorst, Carl T., Breman, Kansas.
Ch. BRAUN, ANNETTE F., 2702 May St., Cincinnati, Ohio. (F. '25). *Microleptidopt.*
'27. Breakey, E. P., 125 Brittingham Place, Madison, Wis. *Fulgoridæ.*
'29. Brindley, T. A., Sci. Bldg., State College, Ames, Ia. *Ins. Nutrition.*
'27. Brittain, W. H., McDonald College P. O., Quebec, Canada. *Homoptera.*
Ch. BRITTON, W. E., Agr. Exp. Sta., New Haven, Conn. (F. '14). *Aleyrodidæ, Coccidæ.*
'28. Brody, Arthur L., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'19. Bromley, S. W., Bartlett Tree Res. Lab., Stamford, Conn. *Asilidæ.*

Ch. Brooks, Fred E., French Creek, West Va. *Fruit and Nut Insects.*
'28. Brown, F. Martin, Avon College, Avon, Conn. *Piesidæ.*
'26. Brown, W. J., Ent. Branch, Dom. Dept. Agr., Ottawa, Can. *Coleoptera.*
'28. Bruce, Wesley G., State College Station, Fargo, North Dakota.
Ch. BRUES, C. T., Bussey Inst., Boston 30, Mass. (F. '14). *Hymenoptera.*
'30. Bruner, S. C., Estacion Exptl. Agr., Santiago de las Vegas, Havana, Cuba.
Ch. BRUNER, LAWRENCE, 3033 Deakin St., Berkeley, Cal. (F. '07). *Orthopt.*
'28. Brunson, M., Picayune, Miss.
'28. Brunson, M. H., Box H., Moorestown, New Jersey. *Truck Insects.*
'19. Bryan, Edwin H., Jr., Bishop Mus., Honolulu, Hawaii. *Diptera.*
'30. Bryant, Owen, Banff, Alberta, Canada.
'23. Bryson, H. R., Dept. Ent., Agr. College, Manhattan, Kan. *Elateridæ.*
'28. Buckell, Edw. D., Ent. Lab., Box 308, Vernon, Brit. Col., Canada. *Orthoptera.*
'22. Bulger, Jacob W., Bur. of Ent., Washington, D. C. *Physiology.*
Ch. BURGESS, A. F., 964 Main St., Melrose Highlands, Mass. (F. '17). *Carabidæ.*
'28. Burrell, R. W., 70 Groveland St., Arlington, Mass. *Parasitoid Ins.*
'28. Burris, T. H., R. D. 10, Ballinger, Texas. *Ichneumonidæ.*
'29. Bushey, C. J., Olivet College, Olivet, Ill. *Chrysochus.*
'29. Butcher, Fred D., Extension Service, Iowa Agr. College, Ames, Ia.
'28. Butler, H. G., 2303 W. Douglas Ave., Wichita, Kansas.
'19. Buys, John L., St. Lawrence Univ., Canton, N. Y. *Cicadellidæ.*
'24. Byers, C. F., Dept. Biol., Univ. of Fla., Gainesville, Fla. *Odonata.*

'12. CAESAR, LAWSON, Ont. Agr. College, Guelph, Ont., Canada. (F. '17).
'26. Caffrey, Donald J., 10 Court Street, Arlington, Mass.
'30. Caler, Horace L., Box 12, Addison, Maine.
Ch. CALVERT, P. P., Zool. Lab., Univ. of Pa., Phila., Pa. (F. '07). *Odonata.*
'24. Camacho, Carlos, Casilla 1248, Santiago, Chile.
'28. Campbell, Frank L., Bur. Entomology, Washington, D. C. *Toxicology.*
'13. Campbell, Roy E., Box 297, Alhambra, Calif. *Syrphidæ.*
'14. *Capp, S. B., Box 2054, Philadelphia, Pa.
'15. Carnochan, Frederic G., New City, Rockland Co., N. Y. *Coleoptera.*
'26. Carpentier, Fritz, Inst. Ed. Van Beneden, 10 Rue Vivegnis, Liege, Belgium. *Morphology.*
'22. Carter, Walter, Pineapple Exp. Sta., Univ. Hawaii, Honolulu, H. I. *Sphecoidea.*
'27. Cartwright, Oscar L., Box 796, Florence, South Carolina. *Cicindelidæ.*
'17. Cartwright, W. B., 600—26th Street, Sacramento, Calif.
'28. Cassidy, Thomas B., Box 1896, Tucson, Arizona.
'24. Cassino, S. E., 20 Naples Road, Salem, Mass. *Geometridæ.*
'18. CAUDELL, A. N., U. S. Nat. Mus., Washington, D. C. (F. '28). *Orthoptera.*
'29. Cecil, Rodney, Agr. Exp. Station, Geneva, N. Y.
'29. Cendana, S. M., Agr. College, Laguna, P. I.
'29. Cerny, Louis F., 1001 West Hills Pky., Lawrence, Kansas.
'14. Chaffee, Mrs. Gertrude B., Amenia, North Dakota. *Collembola.*
'24. Chamberlain, K. F., 17 S. Hawk Street, Albany, N. Y. *Gyrinidæ.*
'22. Chamberlin, Joseph C., Box 2452, Stanford Univ., Cal. *Coccidæ.*
Ch. CHAMBERLIN, R. V., Univ. of Utah, Salt Lake City, Utah. (F. '17). *Arachnida, Myriopoda.*
'17. Chambers, E. L., Office of State Entomologist, Madison, Wis.
'14. Champion, H. G., Forest Research Inst., Dehra Dun, U. P. India. *Coleopt.*
'21. Chandler, S. C., Route 5, Carbondale, Ill.
'28. Chapman, Andrew J., Tallulah, La.
'15. Chapman, J. W., Silliman Institute, Dumaguete, Negros, Philippine Isls.
'14. CHAPMAN, ROYAL N., Univ. of Hawaii, Honolulu, H. I. (F. '28). *Ecology.*
'17. Chermock, H. L., 1308 Tell St., N. S., Pittsburgh, Pa. *Lepidopt., Coleopt.*
'13. Childs, Leroy, Hood River, Oregon.
'29. Christensen, John F., Wellsville, Utah.
'30. Christenson, L. D., Central Baragua, Camaguey, Cuba.
'26. Chu, Yvanting T., St. Johns Univ., Shanghai, China. *Plecoptera.*
'18. CLAASSEN, P. W., Cornell Univ., Ithaca, N. Y. (F. '29). *Plecoptera.*

'28. Clagg, C. F., Fernald Hall, Agr. College, Amherst, Mass. *Mecopt., Hemipt.*
'23. Clark, S. W., Box 548, Weslaco, Texas.
'27. Clarke, L. Floyd, Newton, Utah.
'14. Clausen, Curtis P., Bur. Ent., Washington, D. C. *Insect Parasites.*
'26. Cleveland, C. R., c/o Standard Oil Co., 910 So. Mich. Ave., Chicago, Ill.
'17. Coad, B. R., Tallulah, La.
'07. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (F. '08). *Bees, Fossil Ins.*
'28. Cole, Arthur C., Jr., 2607 Glen Echo Drive, Columbus, Ohio. *Coleoptera.*
'16. Cole, Frank R., 724 Earlham Dr., Whittier, Cal. *Hymenopt., Dipt.*
'27. Coleman, L. V., 4 W. Underwood St., Chevy Chase, Md. *Sense Organs.*
'16. Collins, C. W., Gipsy Moth Labr'y, Melrose Highlands, Mass. *Calosoma.*
'29. Collins, D. L., Bussey Inst., Boston 30, Mass. *Coleopt., Tortricidæ.*
'21. Colman, Wallace, R. D. 1, Silver Springs, Maryland. *Diptera.*
'21. Compton, C. C., 614 S. State Rd., Arlington Heights, Ill. *Greenhouse & Truck Ins.*
Ch. COMSTOCK, JOHN HENRY, 123 Roberts Place, Ithaca, N. Y. (F. '06; H. F. '14).
'29. Conklin, James G., Dept. Ent., Ohio State Univ., Columbus, Ohio.
Ch. Cook, Mel T., Insular Exp. Sta., Rio Piedras, P. R. *Entomogenous Fungi.*
'19. Cook, William C., Montana State College, Bozeman, Mont. *Noctuidæ.*
'10. COOLEY, R. A., State College, Bozeman, Mont. (F. '25). *Ixodidæ.*
'21. Costa-Lima, Angelo da., Casa Luiz de Rezende-Rua do Ouvidor 116, Rio de Janeiro, Brazil. *Chermidæ.*
'15. Cotton, Richard T., Bur. Ent., Washington, D. C. *Curculionid Larvæ.*
'28. Craig, F. W., 1605 Quarrior Street, Charleston, W. Va. *Cicadellidæ.*
'11. *CRAMPTON, GUY C., 86 Pleasant St., Amherst, Mass. (F. '17). *Morphology.*
'12. Creel, Cecil W., Univ. of Nevada, Reno, Nevada.
Ch. CRESSON, E. T., JR., 11 Amherst Ave., Swarthmore, Pa. (F. '25). *Ephydridæ, Micropezidæ.*
Ch. Criddle, Norman, Treesbank, Manitoba, Canada. *Orthoptera.*
'28. Crooks, Clarence A., Box 976, Sandusky, Ohio.
Ch. CROSBY, C. R., Roberts Hall, Ithaca, N. Y. (F. '29). *Arachnida.*
'14. Crossman, S. S., Drawer B., Melrose Highlands, Mass. *Parasitic Hymenopt.*
'28. Crumb, S. E., Box 233, Puyallup, Washington.
'15. Curran, C. H., Amer. Mus. Nat. Hist., New York, N. Y. *Diptera.*
'29. Custer, C. P., Univ. Hospital, Iowa City, Iowa. *Coelioxys.*
'21. Cutright, C. R., Ohio Agr. Exp. Sta., Wooster, Ohio. *Aphididæ.*

'29. Darley, Merrill M., 473 Fourth Ave., Salt Lake City, Utah.
'26. Darlington, P. J., Jr., Mus. Comp. Zool., Cambridge, Mass. *Coleopt., Adephaga and Aquatic.*
'13. Davidson, W. M., R. D. 1, Silver Springs, Maryland.
'28. Davis, A. C., Box 35, Santa Ana, Cal. *Rhyncophora.*
'27. Davis, Cecil N., Bethany, Missouri.
'22. Davis, Edgar W., Box 342, Richfield, Utah. *Cicadellidæ.*
Ch. DAVIS JOHN J., Purdue Univ., Lafayette, Ind. (F. '17). *Aphididæ, Lachnosterna.*
Ch. *DAVIS, WM. T., 146 Stuyv. Place, Staten Isl., N. Y. (F. '17). *Cicadidæ, Orthoptera.*
'13. DEAN, GEORGE A., Kansas State Agr. College, Manhattan, Kan. (F. '17).
'26. Deay, H. O., Dept. Ent., Purdue Univ., Lafayette, Ind. *Coreidæ, Micronecta, Tenagobia.*
'24. Decker, Geo. C., Dept. Ent., State College, Ames, Ia. *Stalk Borers.*
'24. DeCoursey, R. M., Conn. Agr. College, Storrs, Conn. *Hemiptera.*
'28. DeGant, Frank D., 3401 Wade Ave., Cleveland, Ohio. *Ichneumonoidea.*
'17. DeGarnett, R. T., 135 Arbor Drive, Piedmont, Cal. *Buprestidæ Cicadellidæ, Carabide.*
'14. DeGryse, Joseph J., Ent. Branch, Dept. Agr., Ottawa, Canada.
'29. DeKleine, E. H., 201 I Tilden Gardens, Apt. 3000, Tilden Street, N. W., Washington, D. C.
'29. DeLeon, Donald, Forest Insect Sta., Coeur D'Alene, Id. *Scolytidæ.*
'14. DeLong, D. M., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Cicadellidæ.*

'19. Detwiler, J. D., Dept. Zool., Univ. of Western Ontario, London, Ontario.
'28. Dicke, F. F., Box 592, Charlottesville, Va.
'22. Dietrich, Henry, State Plant Board, Lucedale, Miss. *Coleoptera.*
Ch. Dietz, Wm. G., 21 N. Vine Street, Hazelton, Pa. *Tipulidæ.*
'24. Dills, Leslie E., 611 E. Seneca, Ithaca, N. Y.
'26. Dirks, C. O., Dept. Biology, Univ. of Maine, Orono, Maine.
'28. *Doak, K. D., Purdue Univ. Agr. Exp. Sta., Lafayette, Ind. *Gelechiidæ.*
Ch. DOANE, R. W., Stanford Univ., Calif. (F. '25).
'28. Dobbins T. Norman, Montrose, Miss.
'29. Dobroscky, Irene D., Boyce Thompson Inst., Yonkers, N. Y. *Cicadellidæ.*
'28. Dodd, Fred O., R. D. 5, Paris, Ill.
'22. Doering, Kathleen C., 1214 Tenn. Street, Lawrence, Kansas. *Cercopidæ.*
'22. Dohanian, S. M., 42 Cedar St., West Somerville, Mass. *Parasitic Hymenoptera.*
'28. Doner, Melvin H., Dept. Ent., Univ. of Wis., Madison, Wis. *Lepidoptera.*
'29. Dorst, Howard E., 925 Indiana St., Lawrence, Kan. *Cicadellidæ.*
'22. Doucette, Chas. F., Box 566, Sumner, Wash. *Greenhouse Ins.*
'28. Wm. A. Douglas, Cut Off, La. *Sugar cane and rice ins.*
'23. Douglass, J. R., Box 353, Estancia, New Mexico. *Chrysomelidæ.*
'28. Douglass, Nelson L., Box 613, Grenada, Miss.
'28. Dove, W. E., Box 208, Dallas, Texas. *Animal parasites.*
'28. Dove, Walter H., 518 Brightwood Ave., Dayton, Ohio. *Coccidæ.*
'22. Dowden, Philip B., Kay utca 21, Budapest II, Hungary. *Parasitic Hymenopt.*
'28. Dowdle, Verda, Utah Agr. College, Logan, Utah.
'17. Dowell, Philip, 86 Bond St., Port Richmond, Staten Is., N. Y.
'26. Dozier, H. L., Service Technique, Port-au-Prince, Haiti. *Homoptera.*
'22. Drake, Carl J., Iowa State College, Ames, Iowa. *Tingitidæ.*
'25. Duffy, Leo F., Arlington, Vt.
'26. Dunavan, David, Dept. Ent., Clemson College, S. Car. *Carabidæ.*
'23. Duncan, Carl D., Box 4, Stanford Univ., Calif. *Vespidæ, Bembicidæ.*
'30. Dunn, Lawrence H., c/o Gorgas Mem. Labr'y., Box 5025, Ancon, Canal Zone.
'24. Dunn, Melvin B., Ent. Branch, Dept. Agr., Ottawa, Canada. *Forest Ins.*
'28. Dunman, Erastus W., Tallulah, La. *Cotton Insects.*
'16. DuPorte, E. Melville, McDonald College, Quebec, Canada. *Dipt., Ixodoidea.*
'14. Dusham, E. H., Dept. Ent., State College, Pa. *Coleoptera.*

'29. Eagleson, C. W., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Physiol.*
Ch. Eason, N. S., 458 High Street, Fall River, Mass. *Coleoptera.*
'26. Eaton, T. H., Jr., 105 Brandon Pl., Ithaca, N. Y. *Lepidoptera.*
'23. Eddy, C. O., Clemson College, S. Carolina.
Ch. Edwards, Edwin H., 1548 Rockway, Lakewood, Ohio. *Coleopt., Lepidopt.*
'24. Elmore, John C., Box 66, Garden Grove, Calif.
'30. Elmore, L. C., Snowville, Va. *Diptera, Coleoptera.*
'17. Elrod, M. J., State Univ., Missoula, Mont.
'28. Elson, J. A., Gustavus Adolphus College, St. Peter, Minn. *Hemiptera.*
'11. Ely, Charles R., 6 Kendall Green, Washington, D. C. *Gracilariidæ.*
'19. Emerson, A. E., Dept. of Zool., Univ. of Chicago, Chicago, Ill. *Isopt.*
Ch. EMERTON, J. H., 30 Ipswich Street, Boston, Mass. (F. '07). *Spiders.*
'14. Enburg, John M., 5141 Baltimore Ave., Philadelphia, Pa.
'26. Enders, H. E., 249 Littleton St., West Lafayette, Ind. *Mallophaga.*
Ch. Englehardt, G. P., Museum—Eastern Parkway, Brooklyn, N. Y. *Aegeriidæ.*
'26. English, Lester L., Spring Hill, Ala.
'22. Easki, Teiso, Ent. Lab., Kyushu Imp. Univ., Fukuoka, Japan. *Heteroptera.*
'10. ESSIG, E. O., Univ. of Calif., Berkeley, Cal. (F. '27). *Aphididæ, Coccidæ.*
'29. Evans, John H., 502 W. Illinois Street, Urbana, Ill. *Membracidæ.*
'29. Evans, Neal E., 1201 Tennessee St., Lawrence, Kan. *Hydrometridæ.*
Ch. Ewers, Lt. Col. Wm. V., Les Revenants, Somerset, Bermuda.
'10. EWING, H. E., U. S. Nat. Mus., Washington, D. C. (F. '28). *Acarina.*
'18. Eyer, John R., Dept. Biology, State College, New Mexico. *Tineoidea.*

'30. Farquhar, Donald W., 296 Ames Street, Lawrence, Mass.
Ch. FALL, H. C., Tyngsboro, Mass. (F. '07). *Coleoptera.*

'17. Fattig, P. W., Box 788, Emory University, Ga.
'23. Faz, Alfredo, Calle Bandera No. 714, Santiago, Chile, South America.
Ch. FELT, E. P., Bartlett Research Lab's, Stamford, Conn. (F. '08). *Itonididæ.*
'15. Fenton, F. A., 1013 Mills Bldg., El Paso, Texas. *Dryinidæ.*
Ch. FERNALD, H. T., Mass. Agr. College, Amherst, Mass. (F. '14). *Sphecidæ.*
'14. Ferris, G. F., Stanford University, Cal. *Coccidæ, Mallophaga, Anoplura.*
'27. Ficht, G. A., U. S. Corn Borer Lab., Box 359, Monroe, Mich.
Ch. Field, W. L. W., Milton Acad., Vose's Lane, Milton, Mass.
'27. Fife, Lorin, 345 N. Third Street, Logan, Utah.
'22. Filinger, Geo. A., Ohio Agr. Exp. Sta., Wooster, Ohio. *Greenhouse. Ins.*
'10. Fink, D. E., Zool. Lab., Univ. of Pa., Philadelphia, Pa. *Ins. Physiology.*
'28. Fisher, C. K., Box 24, Modesto, Calif.
'07. Fisher, W. S., Nat. Mus., Washington, D. C. *Buprestidæ, Cerambycidæ.*
'22. Fletcher, F. C., 1766 James Ave., So., Minneapolis, Minn. *Pselaphidæ.*
'19. Fletcher, R. K., Box 152, Faculty Exc., College Station, Texas. *Homoptera.*
'08. Flint, W. P., State Ent. Bldg., Urbana, Ill.
'19. Florence, Laura, 445 East 65th Street, Apt. 30, New York, N. Y. *Anoplura.*
'23. Fluke, C. L., 1532 Univ. Ave., Madison, Wis. *Syrphidæ, Bombyliidæ.*
Ch. FOLSOM, J. W., Delta Lab., Tallulah, La. (F. '07). *Collembola, Bombyliidæ.*
'08. *Forbes, W. T. M., Roberts Hall, Cornell Univ., Ithaca, N. Y. *Lepidoptera.*
'22. Ford, Norma, Dept. Biol., Univ. of Toronto, Toronto 5, Canada. *Anatomy, Physiology.*
'19. Fournier, Mrs. Gaston, 90 Boul. Malesherbes, Paris 8, France. *Lepidoptera.*
'26. Fouts, Robt. M., 357 N. Harpers Ave., Hollywood, Calif. *Serphoidea.*
'12. Fox, Henry, Jap. Beetle Lab., Moorestown, N. J. *Orthopt., Scarabaeidæ.*
'11. Fracker, S. B., Federal Horticultural Board, Washington, D. C. *Coreidæ.*
'23. Freeborn, Stanley B., Univ. Farm, Davis, Calif. *Culicidæ.*
'22. Friend, Robt. B., Agr. Exp. Sta., New Haven, Conn. *Diptera.*
'14. FRISON, T. H., Nat. Hist. Bldg., Urbana, Ill. (F. '29). *Bremidæ, Evaniidæ.*
Ch. Frost, C. A., 67 Henry Street, Framingham, Mass. *Coleoptera.*
'14. Frost, S. W., Arendtsville, Pa. *Agromyzidæ.*
Ch. Fullaway, D. T., Board of Agr., Box 3319, Honolulu, Hawaii. *Braconidæ.*
'16. Fulton, B. B., State College, Raleigh, N. Car. *Orthoptera.*
'11. FUNKHOUSER, W. D., Univ. of Kentucky, Lexington, Ky. (F. '20). *Membracidæ.*

Ch. GAHAN, A. B., Nat. Mus., Washington, D. C. (F. '28). *Chalcidoidea, Braconidæ.*
'28. Gahm, Otis E., Bur. Ent., Washington, D. C. *Mushroom Insects.*
'16. Gaige, F. M., Mus. of Zool., Univ. of Mich., Ann Arbor, Mich. *Ants.*
'28. Gamble, John T., 64 Eagle Street, Greenville, Pa. *Aquatic Coleoptera.*
'22. Garlick, W. G., Vineland Station, Ontario, Canada. *Tenthredinoidea.*
'14. Garman, Philip, Agr. Exp. Sta., New Haven, Conn. *Odonata, Acarina.*
'28. Garrison, G. L., Tallulah, La.
'22. Gehring, John George, Bethel, Maine. *Coleoptera.*
'28. Geist, Robert M., 811 Euclaire Ave., Columbus, Ohio. *Mallophaga.*
'16. Gentner, Louis G., Box 877, Medford, Oregon. *Halicinæ.*
Ch. Gerhard, Wm. J., Field Mus. Nat. Hist., Chicago, Ill. *Hemiptera.*
'22. Gerry, B. I., Bussey Inst., Forest Hills, Mass.
Ch. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Canada. (F. '17).
'12. Gibson, E. H., 512 Old Orchard Rd., Ten Hills, Baltimore, Md. *Hemipt.*
'30. Gillespie, A. M., Phi Eta Kappa, Univ. Maine, Orono, Me.
Ch. GILLETTE, C. P., Fort Collins, Colo. (F. '07). *Aphididæ.*
'28. Gilliatt, F. C., Ent. Lab., Annapolis Royal, Nova Scotia. *Tortricidæ.*
'22. Gilmer, Paul M., 2303 W. Douglas Ave., Wichita, Kansas.
'16. Glaser, R. W., Rockefeller Med. Res. Inst., Princeton, N. J. *Ins. Diseases.*
'11. Glasgow, Hugh, N. Y. Agr. Exp. Sta., Geneva, N. Y.
'11. Glasgow, R. D., State Education Bldg., Albany, N. Y. *Phyllophaga.*
'21. Good, Henry G., Ala. Poly. Inst., Auburn, Ala. *Coleoptera.*
Ch. Graenicher, S., Box 14, South Miami, Fla. *Muscoidea, Aculeata.*
'24. Graf, John E., Bur. Ent., U. S. Dept. Agr., Washington, D. C.
'17. Graham, S. A., Sch. of Forestry, U. of Mich., Ann Arbor, Mich. *Timber Ins.*
'22. Granovsky, A., 1532 Univ. Ave., Madison, Wis. *Aphididæ.*

'26. Grant, U. S. IV., Nat. Hist. Mus., Balboa Park, San Diego, Calif.
'28. Gray, John, College of Agr., Gainesville, Fla. *Embryology.*
'14. Greene, Charles T., Box 182, College Park, Md. *Diptera.*
'24. Greer, A. H., Room 8, Federal Bldg., El Paso, Tex. *Heterocera, Culicidæ.*
'28. Grimes, Dillard W., Box 125, Durant, Miss.
'19. Griswold, Grace H., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'24. Gui, Harry L., Agr. Exp. St., Wooster, Ohio.
'29. Guthrie, Howard E., Dept. Ent., Iowa Agr. College, Ames, Iowa. *Coccidæ.*
'21. Guyton, F. E., Auburn, Ala. *Cicadellidæ.*
'16. Guyton, T. L., Bur. Pl. Ind., Pa. Dept. of Agr., Harrisburg, Pa. *Aphididæ.*

'26. Haber, Vernon R., Dept. Ent., Pa. St. College, Pa. *Orthroptera.*
'27. Hadden, F. C., Box 411, Honolulu, Hawaii. *Bostrychidæ, Histeridæ.*
'23. Hadley, Charles H., Box 361, Camden, New Jersey.
'24. Haeussler, G. J., V. Mon Toit, Chemin du Tamisier, Antibes, Alps Maritimes, France.
'14. Hagan, Harold R., Wahiawa via Honolulu, Hawaii.
'26. Haigh, Margaret, 462 Garrison W., Dearborn, Mich. *Lepidoptera.*
'29. Haines, K. A., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'26. Hall, David G., Agr. College, Manhattan, Kansas. *Sarcophagidæ.*
'22. Hall, M. C., Bur. Animal Industry, Washington, D. C. *Parasites of Domestic Animals.*
'14. Hallinen, J. E., Coopertown, Okla.
'21. Hallock, H. C., Box 764, Westbury, Long Isl., N. Y. *Sarcophagidæ.*
'14. Hamilton, C. C., Rutgers, New Brunswick, N. J. *Larvæ of Cincindelidæ, Carabidæ.*
'16. Hamlin, J. C., 473 Fourth Ave., Salt Lake City, Utah. *Membracidæ, Chelinidæ.*
'22. Hamner, A. L., Box 203, A. & M. College, Miss. *Aphididæ.*
Ch. Hansen, James, St. Johns Univ., Collegeville, Minn.
'30. Hardy, Christine, Chesham, New Hampshire.
'07. *HARNED, R. W., A. & M. College, Miss. (F. '28).
'29. Harries, F. H., 473 Fourth Ave., Salt Lake City, Utah.
'23. Harris, H. M., Dept. Ent., State College, Ames, Iowa. *Hemiptera.*
'28. Harris, J. P., Union Trust Co., Cleveland, Ohio.
'28. Harrison, Perry K., Dept. Ent., Univ. of Maryland, College Park, Md.
'24. Hart, Cecil, 132 N. Third Street, Montibello, Calif.
'20. Hartzell, Albert, Boyce-Thompson Inst., Yonkers, N. Y. *Cicadellidæ.*
'07. Hartzell, F. Z., Agr. Exp. Sta., Geneva, N. Y. *Coleoptera.*
Ch. Haseman, Leonard, Univ. of Missouri, Columbia, Mo. *Psychodidæ.*
'19. Hatch, M. H., Dept. Zool., Univ. of Wash., Seattle, Wash. *Coleoptera.*
'29. Hatfield, Nicholas W., 3302 Fall Creek Blvd., Indianapolis, Ind.
'28. Hawkins, J. H., Agr. Exp. Sta., Orono, Me. *Noctuid Larvæ.*
'19. HAYES, WM. P., Old Law Bldg., Univ. of Ill., Urbana, Ill. (F. '29). *Larvæ.*
Ch. HEADLEE, THOMAS, J., New Brunswick, New Jersey. (F. '20).
'28. Hearle, Eric, Ent. Labr'y, Kamaloop, Brit. Col., Canada. *Biting Flies.*
'27. Hendrickson, Geo. O., Dept. Ent., State College, Ames, Ia. *Ecology.*
'28. Henneberry, T. V., 75 School Street, Manchester, Mass.
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'29. Hering, Paul E., Dept. Biol., Rensselaer Poly. Inst., Troy, N. Y.
'26. HERMES, W. B., Univ. of Calif., Berkeley, Cal. (F. '29). *Med. Ent.*
'29. Herr, E. A., Exp. Sta., Oak Harbor, Ohio. *Lepidoptera, Diptera.*
Ch. HERRICK, GLENN W., 219 Kelvin Pl., Ithaca, N. Y. (F. '14). *Thysanoptera, Coccidæ.*
'17. Hertzog, P. H., Highstown, New Jersey.
'16. Hess, W. N., Hamilton College, Clinton, N. Y. *Lampyridæ.*
'08. Heywood, Mrs. R. E., The Oaks, Peterson, Iowa. *Odonata.*
'28. Hickman, Jennings R., Normal College, Ypsilanti, Mich. *Haliplidæ.*
'29. Hiestand, Wm. A., Univ. of Wis., Madison, Wis. *Coleoptera.*
'26. Higgins, M. L. J., Rood Ave., Sta. 14½, Windsor, Conn. *Coleoptera.*
'19. Hill, Charles C., 337 Franklin Street, Carlisle, Pa.
'08. Hilton, W. A., 1263 Dartmouth Ave., Claremont, Cal. *Compodea, Japyx.*

'28. Hiltz, J. R., 240 Florence Ave., Pontiac, Mich.
Ch. HINDS, W. E., State Univ., Baton Rouge, La. (F. '25).
Ch. Hine, J. S., Archaeol. Mus., Ohio State Univ., Columbus, Ohio. *Diptera.*
'28. Hinman, E. H., 105 N. Quarry Street, Ithaca, N. Y. *Culicidæ.*
'27. Hockenyos, George L., 1003 Oregon Street, Urbana, Ill.
Ch. Hodgkiss, H. E., Exp. Sta. Bldg., State College, Pa. *Eriophyidæ.*
'29. Hodsom, Alex. C., Zool. Dept., U. of Minn., Minneapolis, Minn. *Trichopt.*
'29. Hodson, Elmer C., 48 Sherwood Street, Roslindale, Mass.
'14. *Hoffman, Wm. A., School of Trop. Med., San Juan, P. R. *Biting Flies.*
'29. Hoffman, Clarence H., 1133 Rhode Island St., Lawrence, Kansas.
'19. Hoffman, W. E., c/o Trustees, Lingnan Univ., 150 5th Ave., New York, N. Y. *Hemipt.*
'28. Holdaway, F. G., Faculte des Sci. Zoo., Univ. de Toulouse, Allee St. Michel, Toulouse, France.
Ch. HOLLAND, W. J., Carnegie Mus., Pittsburgh, Pa. (F. '07). *Lepidoptera.*
'13. Holoway, T. E., 8203 Oak Street, New Orleans, La.
'12. Hood, C. E., Melrose Highlands, Mass.
Ch. Hood, J. D., Dept. Biol., Univ. of Rochester, Rochester, N. Y. *Thysanopt.*
'28. Hopping, Ralph, Box 308, Vernon, Brit. Col., Canada. *Timber Ins.*
'13. Horton, J. R., 126 S. Minneapolis, Ave., Wichita, Kan. *Phyllophaga, Ants.*
'23. Hottes, F. C., Dept. Biol., Jas. Millikan Univ., Decatur, Ill. *Aphidadæ.*
'24. Hough, Walter S., Winchester, Va. *Apple Insects.*
Ch. Houser, J. S., Ohio Agr. Exp. Sta., Wooster, Ohio. *Coccidæ.*
Ch. Howard, Chas. T., 36 Colby Street, Rochester, N. Y. *Lepidoptera.*
Ch. HOWARD, L. O., Bur. Ent., Washington, D. C. (F. '07; H. F. '24). *Chalcidoidea.*
'14. Howard, Neale F., 151 West 11th Ave., Columbus, Ohio. *Mex. Bean Beetle.*
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'23. Hubbell, T. H., Dept. Biol., Univ. of Fla., Gainesville, Fla. *Orthoptera.*
'21. Huber, L. L., Agr. Exp. Sta., Wooster, Ohio. *Chalcidoidea.*
'19. Huckett, H. C., R. D., Calverton, Long Isl., N. Y. *Anthomyiidæ, Muscids.*
'28. Hudson, H. F., R. R. 2, Strathroy, Ontario, Canada. *Noctuidæ.*
'22. Hull, Frank M., Plant Lice Lab., Dickinson, Texas. *Diptera.*
'09. Hungate, J. W., State Normal School, Cheney, Washington.
'16. HUNGERFORD, H. B., Mus. Bldg., K. U., Lawrence, Kan. (F. '28). *Aq. Hemipt.*
Ch. HUNTER, S. J., Lawrence, Kansas. (F. '21).
'17. Hussey, R. F., Dept. Biol., New York Univ., Wash. Sq., New York, N. Y. *Hemipt.*
'26. Hutchinson, W. L., 93 N. Church Street, Hazleton, Pa. *Coleoptera.*
'08. Hyslop, J. A., Silver Spring, Md. *Elateridæ.*

'11. *Illingworth, J. F., Bishop Museum, Honolulu, Hawaii. *Muscoidea.*
'28. Inaba, Naomichi, 207 Harajiku Akasaka, Tokyo, Japan. *Lepidoptera.*
'28. Ingram, J. W., 8203 Oak Street, New Orleans, La.
'26. Irish, Henry Clay, 911 Locust Street, St. Louis, Missouri.
'14. Isely, Dwight, 3 N. Duncan St., Fayetteville, Ark. *Chrysomilidæ.*
'22. Ishimori, Naoto, Faculty of Agr., Imp. Univ., Tokyo, Japan. *Lepidopt.*
'27. Ives, J. D., Carson & Newman College, Jefferson City, Tenn. *Cave Ins.*

'07. Jackson, C. F., Durham, N. H. *Ecology.*
'15. Jackson, L. O., High Sch., Colorado Springs, Col. *Hymenopt.*
'28. Jahn, Lydia A., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Diptera.*
'24. Janvrin, E. R. P., 38 E. 85th Street, New York, N. Y. *Coleoptera.*
'30. Jaynes, H. A., Casilla Correo 74, Tucuman, Argentina, South America.
'25. Jeannel, R., Mus. D'Hist. Nat., 57 Rue Cuvier, Paris 5, Fr. *Trechus, Anophthalmes.*
'10. Jennings, H. R., High Sch., Hayes & Van Ness Ave., San Francisco, Cal. *Dipt.*
'15. Jewett, H. H., 112 State Street, Lexington, Kentucky.
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'27. Johnston, H. G., Dept. Ent., College Station, Texas. *Miridæ.*
'26. Jones, Dettmar W., 10 Court Street, Arlington, Mass. *Tachinidæ.*
'29. Jones, Edward W., Dept. Ent., Univ. Farm, St. Paul, Minn. *Elateridæ.*
'28. Jones, Elmer T., 126 S. Minneapolis, Ave., Wichita, Kansas.
Ch. Jones, Frank M., 2000 Riverview, Ave., Wilmington, Del. *Psychidæ.*
'28. Jones, Luther G., Drawer 359, Monroe, Michigan.
'28. Jones, R. M., State Fruit Exp. Sta., Mountain Grove, Mo.
'26. Jones, W. Russel, R. F. D., 11, Box 63-B, Pensacola, Fla. *Hymenopt.*

'16. Kahl, Hugo, Carnegie Mus., Pittsburgh, Pa. *Odonata.*
'27. Kamal, Mohammed, Cotton Res. Board, Giza, Egypt. *Syrphidæ, Coccidæ.*
'29. Keck, Chester B., Box 491, Orlando, Fla.
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'23. Kelley, E. G., State Agr. College, Manhattan, Kansas.
'24. Kelsheimer, E. G., Corn Borer Lab., Oak Harbor, Ohio. *Behavior.*
'14. KENNEDY, C. H., Ohio State Univ., Columbus, Ohio. (F. '28). *Odonata.*
Ch. Kincaid, Trevor, Univ. of Wash., Seattle, Wash. *Psychodidæ, Tenthredonidea.*
'28. King, Geo. E., c/o Chazy Orchards Inc., Chazy, N. Y. *Hymenoptera.*
'14. King, H. H., Wellcome Trop. Res. Lab., Khartum, Sudan, Afr. *Dipt.*
'12. King, J. L., Jap. Beetle Lab., Moorestown, New Jersey. *Diptera.*
'23. King, K. M., Univ. Sask., Saskatoon, Sask., Canada. *Noctuidæ, Cicadellidæ.*
'28. King, Willard V., Mound, La.
'18. KINSEY, ALFRED C., Ind. Univ., Bloomington, Ind. (F. '28). *Cynipidæ.*
'28. Kislanko, J. P., Box 88, Wiggins, Miss. *Aphididæ.*
Ch. KNAUS, W., McPherson, Kansas. (F. '20). *Coleoptera.*
'11. KNIGHT, HARRY H., State Univ., Ames, Iowa. (F. '28). *Miridæ.*
'24. Knowlton, Geo. F., Utah Agr. Exp., Logan, Utah. *Aphididæ.*
'26. Kofoid, Charles A., Univ. of Calif., Berkeley, Calif. *Termitidæ.*
'17. Kraatz, Walter C., Univ. of Akron, Akron, Ohio.
'23. Kuwayama, Satoru, Hokkaido Agr. Exp. Sta., Kotoni, Saporo, Japan. *Neuroptera, Trichoptera, Psyllidæ.*

'14. Laake, E. W., Box 208, Dallas, Texas. *Larval Muscidæ, Oestridæ.*
'24. Lacey, John S., 133 Waldo Street, Holyoke, Mass.
'19. LaCroix, D. S., 24 N. Prospect Street, Amherst, Mass.
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'28. Lamiman, J. F., 210 Agr. Hall, Univ. Calif., Berkeley, Cal. *Acarina.*
'12. Lamkey, Ernest M. R., 505 So. Fell Ave., Normal, Ill.
'28. Lancaster, Horace, Parma, Idaho. *Thysanoptera, Elateridæ.*
'30. Landis, B. J., 153 Calzada Tacuba, San Jacinto, Mexico City. Mex.
Ch. Lang, Joseph N., 1433 S. 59th Ave., Cicero, Ill. *Lepidoptera.*
'17. Lange, R. C., 527 Ivanhoe Pl., Webster Groves, Mo. *Coleopt., Lepidopt.*
'26. Langford, Geo. S., Dept. Ent., Univ. Maryland, College Park, Md.
'17. Langston, J. M., Box I, A. & M. College, Miss. *Phyllophaga.*
'14. Larrimer, W. H., Bur. Ent., Washington, D. C. *Cicadellidæ.*
'26. Larson, Andrew O., 1218 Eye Street, Modesto, Calif.
'13. Lathrop, F. H., 1237 Fairground Ave., Vincennes, Ind. *Cicadellidæ.*
'19. Lathy, P. I., 90 Bd. Malesherbes, Paris, France. *Lepidoptera.*
'24. Lattimore, Robt. B., 801 Smith Young Tower, San Antonio, Texas.
'23. Lauderdale, Jos. L. E., Box 368, Yuma, Arizona.
Ch. Laurent, Philip, 31 E. Mt. Airy Ave., Philadelphia, Pa.
'27. Lawler, Wm. F., Jr., 38 Murray Street, New York, N. Y. *Satyridæ.*
'17. Lawson. Paul B., 605 Main Street, Lawrence, Kansas. *Cicadellidæ.*
'26. Leach, Frank A., Diable Country Club, Diable, Calif.
'22. Learned, Elmer T., 46 Franklin Street, Fall River, Mass. *Lepidoptera.*
'12. Leiby, R. W., State Dept. Agr., Raleigh, N. Car. *Polyembryony.*
'28. Leonard, M. D., Tobacco By-Products & Chem. Corp., Louisville, Ky.
'27. Letl, Frank H., Dept. of Preparation, Field Museum, Chicago, Ill.
'27. Light, S. F., Dept. Zool., Univ. Calif., Berkeley, Calif. *Isoptera.*

'17. Lindsey, A. W., Box 782, Granville, Ohio. *Hesperioidea.*
'26. List, George M., Colo. Agr. College, Ft. Collins, Colo. *Cimicidæ.*
'24. Liu, Chung Lo, Dept. Biol., Tsing Hua College, Peking, China. *Vespidæ, Bombidæ.*
Ch. Lloyd, J. T., 6624 Kennedy Ave., Cincinnati, Ohio. *Trichoptera.*
'19. Lobdell, Gladys H., Belle Glade, Fla. *Coccidæ, Aleurodidæ.*
Ch. Lockwood, Stewart, 4232 San Benito, Sacramento, Calif.
'30. Loftin, U. C., Sugar Club Exp. Sta., Cent. Baragua, Prov. Camaguey, Cuba.
'26. Long, William W., Eighty-Four, Pa. *Lepidoptera.*
'29. Lott, Earl, 512 Morgan Ave., Palmyra, N. J.
'19. Lowry, P. R., Univ. New Hampshire, Durham, N. H. *Insecticides.*
'13. Luginbill, Philip, 463 Michigan Ave., Monroe, Michigan. *Phyllophaga.*
'17. Lundbeck, Wm., Zool. Mus., Univ. Copenhagen, Copenhagen, Denmark. *Dipt.*
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'28. MacAloney, H. J., Northeast. Forest Exp. Sta., Amherst, Mass. *Timber Ins.*
'28. MacAndrews, A. H., Coll. of Forestry, Syracuse, N. Y. *Timber Ins.*
'24. Macdougal, Alice P., Biol. Dept., Univ. Toronto, Toronto, Canada. *Hemipt.*
'14. McAtee, W. L., Biol. Surv., Dept. Agr., Washington, D. C. *Hemipt.*
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'29. McClanahan, Annie L., Box 184, A. & M. College, Miss.
'29. McClure, H. E., 925 W. Wood Street, Decatur, Ill.
'17. McCracken, Isabel, Box 44, Stanford Univ., Cal. *Cynipidæ, Apoidea.*
'10. McDaniel, Eugenia I., Agr. College, East Lansing, Mich. *Coccidæ, Orthopt.*
'12. MCDUNNOUGH, J., Dept. Agr., Ottawa, Can. (F. '20). *Lepidopt., Ephemerida.*
'25. McGeoch, Charles R., Amherst Agr. College, Amherst, Mass.
'29. McGovran, Edw. R., Dept. Ent., Iowa State College, Ames, Iowa.
'25. McGregor, Ernest A., Box 576, Lindsay, Calif. *Tetranychidæ.*
'20. McIlroy, Wm. D., Jr., 192 Prospect Ave., Ingram, Pa. *Hymenoptera.*
'11. McIndoo, N. E., 7225 Blair Rd., Takoma Park, Washington, D. C. *Physiology.*

'17. Maheux, Georges, Dept. Agr., Parliament Bldg. Quebec, Can. *Timber Ins.*
'28. Maloney, Geo. A., Tallulah, La.
'22. Mank, Edith W., 12 Reservoir Street, Lawrence, Mass. *Coleoptera.*
'21. Mank, Helen G., 12 Reservoir Street, Lawrence, Mass.
'13. *Mann, William M., Nat. Zool. Park, Washington, D. C. *Formididæ.*
'23. Manter, Jerauld A., Agr. College, Storrs, Conn.
'22. Marcovitch, Simon, Agr. Exp. Sta., Knoxville, Tenn.
Ch. MARLATT, C. L., 1521 16th St., N. W., Washington, D. C. (F. '08). *Coccidæ.*
'24. Marshall, M. C., 1096 Ocean Ave., Brooklyn, N. Y.
Ch. MARSHALL, W. S., 139 E. Gilman St., Madison, Wis. (F. '17). *Morphology.*
'26. Martin, Chas. H., 634 S. Washington Ave., Whittier, Calif.
'28. Marvin, Geo. E., 1532 Univ. Ave., Madison, Wis.
'21. Mason, Arthur C., Box 340, Honolulu, Hawaii. *Thysanoptera.*
'12. Mason, P. W., Bur. Ent., Washington, D. C. *Aphididæ.*
Ch. MATHESON, ROBT., Cornell, Univ. Ithaca, N. Y. (F. '28). *Ixodoidea, Culicidæ.*
'28. Maughan, F. B., Wellsville, Utah.
'28. Mayer, Chas. C. B., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Homoptera.*
'28. Maynard, E. A., Dept. Zool., Univ. Rochester, Rochester, N. Y. *Collembola.*
'26. Meiners, Edwin P., 6600 Delmar Blvd., St. Louis, Mo. *Lepidoptera.*
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'28. Melvin, Roy, Dept. Ent., State College, Ames, Iowa. *Physiology.*
'23. Merrill, G. B., State Plant Board, Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
'12. METCALF, C. L., Old Law Bldg., Univ. Ill., Urbana, Ill. (F. '20). *Syrphidæ.*
'09. Metcalf, Z. P., State College Sta., Raleigh, N. Car. *Homoptera.*
'17. Mickel, C. E., Ent. Dept., Univ. Farm, St. Paul, Minn. *Mutillidæ.*
'21. Miller, August E., North Maple Ave., Zanesville, Ohio. *Acarina.*
'28. Miller, D. F., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Ins. Physiol.*

Ch. Miller, Mrs. Ellen R., Lake Wildmere, Longwood, Fla. *Lepidoptera.*
'28. Miller, R. L., State Plant Board, Gainesville, Fla.
'26. Miller, W. C., Bedford High School, Bedford, Ohio. *Hymenopt., Coleopt.*
'29. Mills, H. B., Sci. Bldg., State College, Ames, Ia. *Collembola, Membracidæ.*
'26. Mills, Wier R., Pierson, Iowa. *Lepidoptera.*
'26. Milum, Vern G., 110 Vivarium Bldg., Champaign, Ill. *Apiculture.*
'26. Minnich, D. E., Dept. Zool., Univ. Minn., Minneapolis, Minn. *Behavior.*
'21. Mitchell, Theo. B., N. Car. State College, Raleigh, N. Car. *Apoidea.*
'30. Miwa, Yushiro, Dept. Agr., Gov. Research Inst., Taihoku, Formosa.
'21. *Moffatt, Eliz. M., 1315 Crown Hill Ave., Los Angeles, Cal. *Araneida.*
'28. Mohr, Carl O., State Ent. Bldg., Urbana, Ill. *Coleoptera.*
'22. Montgomery, B. E., Dept. Ent., Purdue Univ., LaFayette, Ind. *Odonata.*
'29. Moody, D. L., Box 133, Presidio, Texas. *Hemiptera, Coleoptera.*
'08. Moore, Wm., 535 Fifth Ave., New York, N. Y. *Insecticides.*
'28. Moreland, R. W., Tallulah, La.
'08. Morgan, Ann H., Mt. Holyoke College, South Hadley, Mass. *Ephemerida.*
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'28. Morgan, W. P., 4105 Otterbein Ave., Indianapolis, Ind. *Dermaptera.*
'28. Morofsky, W. F., Box 771, East Lansing, Mich. *Forest Insects.*
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'12. Morrison, Harold, Bur. Ent., Washington, D. C. (F. '28). *Coccidæ.*
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'08. Mosher, Edna, Adelphi, 282 Lafayette Ave., Brooklyn, N. Y. (F. '20). *Lepidopt.*
'20. Mote, Don C., Oregon Agr. College, Corvallis, Oregon.
'29. Moulton, Dudley, 149 California St., San Francisco, Cal. *Thysanopt.*
'26. Muchmore, L. J., 2009 W. 65th St., Los Angeles, Cal. *Coleopt., Araneida.*
'26. Mueller, Arthur E., 12 Armin Ave., Webster Groves, Mo.
'15. Muesebeck, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. *Braconidæ.*
Ch. Muir, Frederick, Manoa, Durfold Hill, Warnham, Sussex, England. (F. '17). *Fulgoridæ.*
'24. Munro, H. K., Box 513, Pretoria, S. Africa. *Trypetidæ.*
'27. Munro, J. A., State College Sta., Fargo, N. D. *Orthopt., Dipt.*
'28. Murphy, Helen E., Washington College, Chestertown, Mo. *Ephemerida.*
'28. Musgrave, P. N., 514 Mt. Vernon Ave., Fairmont, W. Va. *Chrysomelidæ.*
'17. Mutchler, A. J., Amer. Mus. Nat. Hist., New York, N. Y. *Lampyridæ, Cicindelidæ.*
'15. Muttkowski, R. A., Univ. of Detroit, Detroit, Mich. *Ins. Physiol.*

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'21. Neilson, Ernst A., 143-16 97th Ave., Jamaica, L. I., N. Y.
'21. Neiswander, C. R., Oak Harbor, Ohio. *Aquatic Hemiptera.*
'28. Neiswander, R. B., Dept. Ent., Agr. Exp. Sta., Wooster, Ohio.
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'28. Newton, Richard C., Fernald Hall M. A. C., Amherst, Mass. *Trichoptera.*
'28. Nichol, A. A., Agr. Exp. Sta., Tucson, Ariz. *Coccidæ, Miridæ.*
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'17. *Notman, Howard, 136 Joralemon Street, Brooklyn, N. Y. *Staphylinidæ.*

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'08. O'Kane, Walter C., Durham, N. H. (F. '25).
'16. Olsen, C. E., Amer. Mus. Nat. Hist., West 77th St., New York, N. Y. *Homopt.*

'29. Oman, Paul W., 925 Indiana Street, Lawrence, Kan. *Homoptera.*
Ch. OSBORN, HERBERT, Ohio State Univ., Columbus, Ohio. (F. '07; H. F. '28). *Cicadellidæ.*
'08. Osborn, H. T., Box 208, Central Aguirre, Porto Rico. *Sugar Cane Ins.*
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'20. Otanes, Faustino Q., Bur. of Agr., Manila, P. I.
'17. Ouellett, J. C., Deaf & Dumb Inst., 7400 Boul. St. Laurent, Montreal, Can.
'26. Ozburn, Reginald H., Ontario Agr. College, Guelph, Ontario, Canada.

'15. Packard, Clyde M., Box 495, West Lafayette, Ind. *Orthoptera.*
'18. Painter, H. R., Box 495, West Lafayette, Ind. *Orthoptera.*
'19. Painter, R. H., Ent. Dept., Agr. College, Manhattan, Kan. *Bombylidæ.*
'23. Pallister, J. C., Mus. Nat. Hist., 2717 Euclid Ave., Cleveland, Ohio. *Coleopt.*
'28. Palmer, M. A., Dept. Ent., Agr. College, Ft. Collins, Colo. *Coleopt.*
'28. Park, A. R., Jr., State Nat. Hist. Surv., Urbana, Ill. *Ichneumonidæ.*
'27. Park, Orlando, Dept. Biol., Kent State College, Kent, Ohio. *Lampyridæ.*
'24. Parker, Donald L., 17 East Highland Ave., Melrose Highlands, Mass.
'26. Parker, Harry L., European Parasite Lab., Mont Fenouillet, Hyeres, Var. France. *Behavior.*
'18. Parker, J. B., 1217 Lawrence St., N. E., Washington, D. C. *Bembicidæ.*
'24. Parker, R. L., Dept. Ent., Agr. College, Manhattan, Kan. *Apiculture.*
'16. Parker, R. R., U. S. P. H. S., Hamilton, Mont. *Sarcophagidæ, Acarina.*
'16. Parks, H. B., R. R. 1, Box 368, San Antonio, Texas. *Apiculture.*
'18. Parks, T. H., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'14. Parman, D. C., Box 509, Uvalde, Texas. *Diptera, Siphonoptera.*
Ch. PARROTT, P. J., New York Agr. Exp. Sta., Geneva, N. Y. (F. '14).
'12. Parshley, H. M., Smith College, Northampton, Mass. *Heteroptera.*
Ch. *PATCH, EDITH M., Agr. Exp. Sta., Orono, Me. (F. '14). *Aphididæ.*
'26. Patch, Lawrence H., Box 976, Sandusky, Ohio.
'27. Pate, V. S. L., 5703 N. 6th St., Philadelphia, Pa. *Oxybelinæ, Larridæ.*
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'23. Payne, Nellie M., 431 Pottawatomie Ave., Manhattan, Kan. *Trichopt.*
'19. Peairs, L. M., Morgantown, West Va.
'24. Peltier, Paul X., Snow Hill, Maryland.
'28. Pepper, John O., Agr. Exp. Sta., State College, Pa. *Cicadellidæ.*
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'11. PETERSON, ALVAH, Dept. Ent., Ohio State Univ., Columbus, Ohio. (F. '28).
'07. Petrunkevitch, Alex., Osborn Lab., Yale, New Haven, Conn. *Arachnida.*
Ch. Pettit, R. H., Mich. Agr. Exp. Sta., East Lansing, Mich. *Coccidæ.*
'29. Phillips, Arthur M., Box 2080, Orlando, Fla. *Dipt., Coleopt.*
'21. PHILLIPS, E. F., Cornell Univ., Ithaca, N. Y. (F. '29). *Apiculture.*
'29. Philipps, Griffin L., Baldwyn, Miss.
'12. Philips, W. J., U. S. Ent. Lab., Box 592, Charlottesville, Va. *Harmolita.*
'26. Phipps, Clarence R., Agr. Exp. Sta., Orono, Maine. *Noctuidæ.*
'29. Piatt, Jean, 344 Northern Ave., Indianapolis, Ind. *Odonata, Coleopt.*
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'28. Plank, H. K., Trop. Plant Res. Found., Cent. Baragua, Prov., Camaguey, Cuba. *Parasitic Dipt. & Hymenopt.*
'24. Plath, O. E., 688 Boylston Street, Boston, Mass. *Bremidæ.*
'28. Plummer, Chas. C., Dept. Ent., Ohio State Univ., Columbus, Ohio.
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